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832 A Summary of Current Program 7/1/67 S

2 and Preliminary Report of Progress
for 7/1/66 to 6/30/67

MARKET QUALITY
RESEARCH DIVISION
of the
AGRICULTURAL RESEARCH SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
and related work of the
STATE AGRICULTURAL EXPERIMENT STATIONS

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This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between July 1, 1966, and June 30, 1967. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, U. S. Department of Agriculture.

UNITED STATES DEPARTMENT OF AGRICULTURE

Hyattsville, Maryland 20782

October 1, 1967



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INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at Beltsville, Maryland. Here the Instrumentation Research Laboratory, the Post-Harvest Physiology Pioneering Research Laboratory, personnel of the Field Crops and Animal Products Research Branch, and the Horticultural Crops Research Branch are located. Additional personnel are located in Washington, D. C. There are also 24 field stations located throughout the country; ten of these are located at State Universities or branch Experiment Stations, and two in terminal markets. Total research effort including research contracts amounts to approximately 145 scientist man-years.

Although a large variety of excellent quality fresh and processed agricultural products are retailed at reasonable prices throughout the year there is need for further research on methods to reduce spoilage and waste during storage, transportation and distribution and to improve methods for evaluation of quality. Stored product insects and market diseases still destroy large amounts of produce. Also there is urgent need for new methods of control that will not create health hazards due to pesticide residues. There is increasing need for automated objective methods of quality evaluation to make possible rapid reliable grading and inspection of large quantities of produce under modern packing and handling conditions.

As might be expected an appreciable amount of Market Quality research is related to the effective performance of the Service Divisions of the Consumer and Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. The Division also works closely with industry and other Government Agencies on various problems relating to agricultural commodities in the marketing channels. Specific examples of Market Quality research accomplishments over the past five years are:

Quick Salmonella Test

More rapid procedures were developed for detecting the presence of salmonellae, a group of food poisoning microorganisms, in poultry and egg products. Routine laboratory procedures for detection of these organisms in food products requires a minimum of 4 days, so that in some instances, market distribution of lots of some products may be delayed for this period of time. Under recent USDA and FDA regulations, all egg products must be either pasteurized or otherwise treated to destroy salmonellae. Testing of the product however is still necessary inasmuch as recontamination can occur after treatment. A simple laboratory technique that screens salmonellae-negative samples of dried egg has been developed and is being tested at Beltsville and in a commercial egg-drying plant. The method is based on two biochemical reactions characteristic of most salmonellae, i.e., hydrogen sulfide production and fermentation of mannitol. Failure of either of these reactions to occur when a sample of dried egg is incubated for 42 hours with appropriate media indicates the absence of salmonellae. Only samples showing either reaction need to be tested further. Inasmuch as the majority lots of pasteurized eggs are salmonellae-negative, a great savings in time, equipment and material will be realized by using this technique. Efforts are continuing to refine and shorten this test and to develop more rapid tests for detection of salmonellae-positive samples.

Insect-resistant cotton bag developed

A cotton bag that will protect food and feed against insects as effectively as the already-proven insect-resistant multiwall paper bag has been developed. In cooperative work between the Stored-Product Insects Research Branch and SURDD, the bag was designed, constructed, and exposed for 9 months to a heavy insect infestation. It protected against infestation as well as the paper bag. The bag was constructed of regular cotton sheeting, which had a treatment of pyrethrine-piperonyl butoxide at 6.2-62 mg./sq. ft., a waxed paper liner, and heat sealed paper tape applied over all of the stitched seams. After 9 months' storage, the insecticide residue in the bagged food was well below the 10 p.p.m. tolerance established by FDA for foods in paper bags. The latest estimates of cost for a 100-pound bag such as used in these tests are as low as 41 cents.

The development and use of an insect-resistant cotton bag will benefit U. S. agriculture and the people of developing countries receiving our aid. Cotton bags are an annual market for 70,000,000 yards of cotton sheeting equivalent to 60,000 bales of cotton. The bag is valued by consumers, especially in developing countries, as material for clothing and as income from sale for reuse. Protection against insect infestation reduces food losses and maintains the high quality of the food produced by American industry. Both factors improve our national image abroad.

Critical atmospheres for storage of peaches and nectarines

Research over a period of several years has clearly shown that carbon dioxide concentration is the critical factor in controlled atmosphere storage of peaches and nectarines. Varying the oxygen concentration from 1/2 to 21 percent was ineffective for prolonging storage life without added carbon dioxide. When 5 percent carbon dioxide was added storage life was extended by at least 50 percent at any oxygen concentration from 1 to 21 percent. Internal discoloration, which occurred after 1 month at 32° F. in the absence of carbon dioxide, was completely prevented for 6 to 9 weeks at 32° when 5 percent carbon dioxide was present in the storage atmospheres.

Production of nectarines has been increasing rapidly and will continue to increase. Production in 1954 was less than 20,000 tons. In 1964, it was 75,000 tons with a farm value of \$7,000,000. With increased production, there is need for storage of a considerable part of the production of the late varieties to extend the marketing season. Controlled atmosphere storage appears to be a practical method of avoiding market gluts and extending the period when high-quality nectarines are available to consumers. Preliminary evidence indicates that storage for 8 to 10 weeks is possible at 32° F. if optimum concentrations of O₂ and CO₂ are maintained.

Method for rapid, accurate analysis of moisture and oil content developed

A method for rapid, accurate analysis of moisture and oil content in a wide range of commodities has been developed. Near infrared-absorption technique can be used on any sample which can be prepared into a homogenous thin layer of uniform thickness. Proper choice of wavelength for analysis permits measurement of moisture content on dehydrated materials as well as on tissue from fresh fruits and vegetables. This development should have particular application in laboratory evaluation of composition of agricultural commodities and it should be possible to develop an instrument suitable for grading applications.

This near-infrared-absorption technique has a potential for reducing the time to 5 minutes or less required for making official oil and moisture content determinations. Presently, the official method for soybeans requires an elapsed time of 12 hours, using a hazardous ether extraction process. For meats, three hours elapsed time is required including 30 minutes time of a professional chemist. Less skilled operators could make this direct measurement on a laboratory type instrument.

Carpet beetle sex attractant identified

The attractant that female black carpet beetles produce to attract the males has been isolated and identified as trans-3, cis-5-tetradecadienoic acid. The black carpet beetle is a common pest in homes, food warehouses, and processing plants. The research was performed by Stanford Research Institute under contract with the Stored-Product Insects Research Branch. The attractant has been synthesized, and the male beetles respond to the synthetic material just as actively as they do to the females. Further research is under way to learn how the synthetic material can be used to interrupt or direct the instincts of the insect and thus control its behavior patterns. This should lead to new effective methods for detecting and controlling populations of these insects.

Homeowners spend millions of dollars annually for insecticide sprays and pest control services to combat the black carpet beetle. The damage to wood materials and cereals and other foods is estimated at additional millions. This beetle is difficult to control because, of all the stored-product insects, it is least susceptible to insecticides.

USDA research solves Air Force insect problem

The U. S. Air Force stores and transports thousands of electronic instruments valued at millions of dollars. The best packing material to cushion these instruments during transit is rubberized animal hair. Carpet beetles entered packages during storage and fed on the animal hair, destroying its cushioning quality. Loss of the cushioning material allowed the instruments to be damaged during handling and transit. When this occurred the instruments had to be rechecked or recalibrated at considerable cost. Storage depot personnel had to open hundreds of crates, destroy the hair, eliminate the insect infestations, and repack the items in new hair. This labor and material were very costly.

Knowledge gained in previous research on mothproofing animal fibers enabled MQRD entomologists to develop very quickly a formulation of DDT that protects the hair against carpet beetle feeding but does not affect the cushioning qualities. The experimentally treated hair was found to be completely resistant to insect feeding and satisfactory for all Air Force requirements. The Air Force has adopted the use of this treated hair.

The Air Force has officially acknowledged estimated savings of at least \$300,000 in inspection and repackaging costs alone. Other savings in repair of damage to instruments, wasted shipping and handling time and costs, effects on military readiness, etc., are recognized, but their dollar value cannot be determined. Also, USDA entomologists designed a machine for use by depot personnel in applying the new formulation to the large inventory of untreated hair on hand. This will prevent loss of this hair.

The cost to USDA of the research to solve this problem was \$2,200 (328 man-hours).

EXAMPLES OF RECENT ACCOMPLISHMENTS OF THE

STATE AGRICULTURAL EXPERIMENT STATIONS

California - Effects of Postharvest Gamma Irradiation on Orange Fruits.

Gamma irradiation of orange fruits has been shown to have undesirable effects. Research has demonstrated that gamma irradiation of orange fruit results in increased rate and severity of rind breakdown and greater susceptibility to transit injury. Irradiation also resulted in increased rate of respiration and decreased percent soluble solids. Incidence of decay is lowered by irradiation; but sanitation, cooling, and storage procedures have all been developed to the point where losses from decay are no longer severe. It is unlikely that gamma irradiation will ever be a feasible technology for California oranges in the American trade, but it might be useful to protect oranges from decay in nations where cooling and refrigerated storage and carrier vehicles are lacking.

Wholesomeness of Poultry Carcasses

Wholesomeness of foods means different things to different people. Research on the evaluation of wholesomeness of turkey and chicken carcasses was approved by inoculation of live birds with several common diseases associated with condemnation. The birds were then slaughtered in commercial processing plants. They were inspected by an experienced USDA inspection veterinarian, a trained panel of food technologists and technicians, and an untrained consumer panel of housewives. Results showed (1) a trained veterinarian condemned relatively few birds known to be in an active stage of disease, (2) panels of laymen used few criteria in common with the veterinarian in deciding whether or not poultry carcasses were wholesome, and (3) the trained panel was hypercritical of all carcasses compared with the untrained consumer panel. More research is needed to elaborate the important factors in influencing wholesomeness.

Minnesota - Simple Method for Analysis of the Fatty Acid Composition of Milk Fats.

Since certain milk fats contain short-chain acids, a method was needed that would prevent their loss by volatilization or through incomplete extraction from reaction mixtures. In addition, the method should separate ester derivatives on gas chromatography. Such a method was developed. The new procedure consists of making ethyl esters by transesterification with sodium ethoxide and diethyl carbonate. Extraction of the esters is not necessary and the reaction takes place readily at room temperature.

Missouri - Quality Indicators.

Fungal metabolites are used as indicators of raw product quality and sanitary conditions. Research at the Missouri Agricultural Experiment Station shows the influence of pH on the production of AMC, ethyl alcohol, volatile acids, nonvolatile acids, utilization of sugar by *Rhizopus nigricans*, *Mucor* sp., *Botrytis cinerea*, *Alternaria tenuis*, and *Rhizoctonia*. The nonvolatile acids, expressed as lactic acid, were the most consistent. The other metabolites varied with pH and with the organism. Therefore, lactic acid values offer promise as a single indicator of quality when these organisms are present.

North Dakota - Rust Resistant Large Kerneled Durum.

The North Dakota Agricultural Experiment Station and the Crops Research Division, ARS - USDA, released a rust resistant durum wheat called Leeds. Leeds is the first wheat with improved rust resistance, kernel weight and test weight released through this cooperative effort. Leeds has good milling and macaroni processing qualities; and high wheat and semolina protein. This variety should prove satisfactory in domestic as well as in foreign markets.

Idaho - Reducing Storage Losses and Mechanical Injury To Potatoes.

Optimum conditions for quality maintenance of potatoes have been further defined. Research at the University of Idaho shows that a temperature of 45 to 50 F, with a humidity of 95%, resulted in the best wound periderm formation. Potatoes healed at 45 F formed a greater number of layers of periderm cells than potatoes kept at either 38, 59 or 68 F. Rot and weight loss of potatoes healed at 45 F was less than that found at the other temperatures.

During prolonged storage, temperature control is an absolute necessity, potatoes stored at 45 F have a lower weight loss than potatoes stored at 38 or 52 F, and the quality of potatoes stored at 45 F is higher than potatoes stored at 38 F and equal to the quality of potatoes stored at 52 F.

Potatoes stored at 45 F produced significantly lighter French fry color than those stored at 42 F, and only a slightly darker French fry color than tubers stored at 48 F. There is very little difference between the build-up of sugars in tubers stored at 45 and 48 F, but tubers from both temperatures are significantly lower in sugars than tubers of the same lot stored at 42 F.

Illinois - A New Test for Quickly Determining the Maturity and Flavor of Sweet Corn.

The maturity of sweet corn at harvest is extremely important to the consumer. Numerous tests such as the "thumb nail" test, moisture content and density by immersion in water, are available but these tests are too time consuming or inaccurate. Density determinations of expressed juice can be made in a period of 15 minutes. Density is highly correlated with the vacuum oven moisture. Flavor and density also are highly correlated. Sweet corn processors are now evaluating the density method for their quality control program.

New York - Geneva - Snap Bean Quality Control.

A simple rapid method is needed to control snap bean quality. Such a method could guide producers so that they would obtain maximum yield and provide the processor with good quality raw product. In commercial testing, it was shown that seed length measurements from 4 sieve or 5 sieve diameter pods provide a rapid, continuous, accurate method for maturity control. Records of seed length and sieve size also indicate changes in raw product supplies due to unfavorable growing conditions.

Texas - Conditioned Air for Quality Maintenance in Stored Grain.

"The preservation of product quality during storage has tremendous economic importance and also influences the safety and health of the general public." "Stored-product insects become inactive and eventually die of starvation at temperatures of 50° to 60° F. Therefore, controlled environment storage in which the temperature is maintained below 60° F. offers a solution to insect control problems and the elimination of residue hazards as well as loss in quality from molds and heat damage."

AREA 1

CITRUS AND SUBTROPICAL FRUIT - MARKET QUALITY

Problem. Research is needed to develop better objective indices for measurement of quality of citrus and other subtropical fruits. This would result in more meaningful grades and standards which could be better enforced. Instrumentation and automatic devices for quality sorting on a commercial basis might be possible. Decays and fruit soilage present serious problems in both domestic and export markets. Much research is needed to relate mechanical harvesting, handling practices, packaging, precooling and transit refrigeration to wastage, and to develop effective treatments for decay reduction. There is need for further research on controlled atmosphere storage for citrus and other subtropical fruits. Problems which are sometimes distinct and sometimes interrelated exist in each of the geographical areas. These often require biological research in the separate production areas for solution.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. Research is conducted in the producing areas of California, Florida and Texas. Market studies are made in Belle Mead, New Jersey and Chicago. P. L. 480 grants are operative for studies in India on identification and mode of infection of fungi causing postharvest rots of tropical fruits; in Spain on detection of additives in citrus juices; in Germany on the antimicrobial action of biphenyl; in Israel on maturation and ripening of avocados; and in India on metabolic changes during ripening of mangos. A contract study on citrus fruit quality as related to mechanical harvesting will be completed in November 1967 at the Citrus Experiment Station, Lake Alfred, Florida.

Total federal scientist man-years devoted to this area is 11.0. Of this 1.5 is devoted to objective measurement of quality; 1.2 to quality maintenance during handling; 3.4 to quality maintenance during storage; 1.0 to quality maintenance during transportation (with emphasis on export); 1.0 to post-harvest physiology; and 2.9 to postharvest disease control. P. L. 480 projects in this area involve \$29,732 equivalent over a 5-year period in India; \$56,163 equivalent over a 4-year period in Spain; \$77,138 equivalent over a 5-year period in West Germany; \$83,620 equivalent over a 5-year period in Israel; and \$45,344 equivalent for a second 5-year project in India.

Projects terminated during this period included: methods to improve quality of grapefruit on European markets (MQ 2-74); and aromatic polynuclear hydrocarbons on citrus fruits (MQ 3-46).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 10.0 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Non-Destructive Sorting of Citrus Fruits for Quality. Hamlin and Valencia oranges from the Orlando laboratory were evaluated at Beltsville on the basis of percent soluble solids, titratable acidity, and Brix acid ratio. Before shipment both varieties had been sorted by eye into 3 groups, according to orange color. Variation of individual oranges within color groups was too great for significant quality differences between groups. Brix-acid ratios for Hamlin averaged 11.6 to 13.4, while Valencia averaged 10.6 to 10.9.

Tests at Orlando on the commercial light reflectance sorter were completed. All tests were made on washed fruit. Sorting for degreening requirement in Hamlin oranges, uniformity of color in Hamlin and Temple oranges and limes and defects of oranges was successful. Decay was significantly higher with advanced maturity, more hours of degreening and weeks of storage. However, initial fruit color had no effect on decay. The biweekly maturity tests on Hamlin and Valencia oranges and Marsh grapefruit show that of 24 measurements in each of 3 seasons, 17 to 19 indicated maturity changes. (MQ 3-77)

2. Seasonal Changes in Florida Persian Limes. Limes from 3 different groves were analyzed for ascorbic acid for 5 consecutive months. Small limes contained more ascorbic acid than large limes. Limes 1-7/8", 2-1/8", and 2-3/8" in diameter averaged 30, 27, and 23 mg. of ascorbic acid per 100 ml. of juice, respectively. Ascorbic acid content also varied between groves. The average ascorbic acid content of limes of all sizes from 3 groves was 31, 26, and 23 mg. per 100 ml. of juice. (MQ 3-53)

3. The Detection of Additives in Citrus Juices. Continuation of this P. L. 480 project in Spain has developed useful clues to adulterants in citrus juices. Data on proportions of mineral constituents, amino acids and flavonoids in pure juices have been obtained. The relation of acidity to quality and purity has been clarified. The development and adoption of simplified, accurate methods of analysis for major and minor components of juice would be of great benefit in commercial detection of adulterants. (E25-AMS-6)

B. Quality maintenance in handling and packaging

1. Citrus Fruit Quality as Related to Mechanical Harvesting. This contract research with the Florida Experiment Station was completed during

the 1966-67 season. Hand harvesting consistently caused less immediate damage and decay during holding than mechanical tree or limb shaking. Of the orange varieties tested, Hamlins showed the least damage and Pineapples the most from mechanical harvesting. Marsh grapefruit generally showed less damage than oranges. Fruit splitting and puncturing are the principal types of damage. Plugged fruit (rind torn at stem end) has generally been less of a problem with mechanically harvested than with hand harvested oranges. (MQ 2-65)

C. Quality maintenance in storage

1. Controlled Atmosphere Storage of Florida Citrus Fruits. Of the various atmospheres tried, 15% O₂-0% CO₂ resulted in the best flavor retention of Valencia and Temple oranges and Orlando tangelos. Unwaxed Valencias stored in 15% O₂ with 0, 2.5, or 5% CO₂ for 12 weeks at 34° F. had higher flavor ratings than comparable fruit stored in other atmospheres or in air. Waxed fruit stored in CA were lower in flavor and had more decay than unwaxed fruit. Less decay developed in fruit held in CA than in air storage. Off-flavors developed in fruit held in 5% O₂ with 0, 2.5, or 5% CO₂. Excessive decay followed 20-week CA and air storage. Air storage at 35° F. was most effective for Orlando tangelos up to 6 weeks. Results at 40° were similar in air and 15% O₂ with 0, 1, or 2.5% CO₂. Stem-end decay increased as O₂ concentration decreased and as CO₂ increased. Temple oranges stored 5 weeks in 15% O₂-0% CO₂ at 35° F. developed no decay and less than 2% chilling injury. More chilling injury occurred in air at 35°.

Acetaldehyde, ethyl alcohol, pinene, sabinene, myrcene, limonene, and octanol were the predominant volatile components present in the citrus fruits tested. Ethyl alcohol, which increased with reduced oxygen and with waxing, showed more variation during storage than other components. Ethylene-treated fruit contained an unidentified volatile component that was not present in non-ethylened fruit. (MQ 2-110)

2. Controlled Atmosphere Storage of California Oranges. Valencia oranges stored at 42° F. with carbon dioxide concentrations of 10% and 20% were off-flavor after 1 month of storage and showed rind injury after 2 months. After 3 months of storage, the control fruit in air was rated best in flavor, with the treated fruit from 21% oxygen and zero CO₂ next. Oranges held in 5% oxygen without CO₂ for 3 months were off-flavor. (MQ 2-98)

3. Controlled Atmosphere Storage of Texas Grapefruit. Grapefruit harvested in late-December showed the least decay when stored in carbon dioxide-free atmospheres. Decay was almost 12 times greater in fruit held in 5% CO₂ after 18 weeks. Oxygen levels from 1.5% to 10% did not affect decay development. Penicillium green mold was responsible for nearly all decay. One lot of grapefruit from the upper Valley which was stored at 45° F. in 10% oxygen and zero carbon dioxide, showed less than 6% decay after 18 weeks in CA plus 1 week in air and an additional 1 week at 70°.

Peel color was retained best in fruit held in atmospheres containing 1.5% oxygen. It was nearly as good in fruit stored in 5% oxygen. Fruit held in 10% oxygen acquired an orange peel color with the blush faded and was similar in appearance to fruit stored in air. Peel color was not affected by the levels of carbon dioxide maintained in the different atmospheres. Rind pitting was least at the higher CO₂ levels. (MQ 2-98)

4. Controlled Atmosphere Storage of Florida Avocados and Limes. Lula avocados retained higher quality after 30, 45, and 60 days in CA storage at 50° F. than comparable fruit stored in air. After 60 days' storage, all avocados stored in 1% O₂-9% CO₂ were marketable, making this the most satisfactory atmosphere tested. Only unwaxed limes subjected to a minimum of handling were satisfactory for CA storage tests. Waxed fruit had too much decay and rind injury. Limes stored in 10% O₂-7% CO₂ at 50° F. retained green rind color for 60 days, but limes in air were too yellow after 30 days. Fruit from atmospheres containing 15% CO₂ developed a severe discoloration of the rind. Juice content of limes usually decreased in CA and increased in air. (MQ 2-110)

D. Quality maintenance during transportation

1. Export Shipment of Texas Grapefruit. A refrigerated van test shipment of red grapefruit was made to West Germany in January 1967. Transit temperature in the van was not optimum. Slow cooling of the grapefruit indicated a short-circuiting in the air flow. A modification in the loading pattern to include a solid, top layer of containers would have been beneficial. (MQ 2-139)

2. Export Shipments of California Citrus Fruit. Average transit temperatures of 13 test shipments of citrus from California to Rotterdam were 46° to 53° F. All the biphenyl residues of the 4 orange and 4 lemon shipments analyzed to date were below the legal tolerance of 70 parts per million on arrival, but some oranges exceeded the tolerance after holding 1 week in the shipping container without refrigeration to simulate wholesale distribution. (MQ 2-139)

E. Postharvest physiology

1. Maturation and Ripening of Avocados. The annual report on this P. L. 480 project in Israel has not been received. A progress report through October of 1966 indicated substantial progress in development of methods for determination of auxins and inhibitors. Avocado tissue cultures have been prepared on artificial media for studies on response to natural and synthetic growth substances. (A10-MQ-2)

2. Metabolic Changes in Mangos During Ripening and Storage. This P. L. 480 project, initiated in India in 1966, has not progressed to positive findings. Several Indian varieties of mangos were used in storage tests and for compositional studies. Chilling injury to the fruit occurred at

holding temperatures below 41° F. Total protein content did not change during postharvest ripening but the proportion of several amino acids changed significantly. Ascorbic acid content decreased during ripening. Indirect evidence indicated that methionine is a precursor for ethylene. The activity of catalase and peroxidase associated with oxidation increased during ripening. (A7-MQ-6)

3. Stylar-End Breakdown of Limes. When stylar-end breakdown was not prevalent in limes from groves and packing houses of the area, handling had little or no effect on the incidence of the disorder. Conversely, when the disorder was prevalent, bruising increased it. Bruising does not cause stylar-end breakdown, but increases the disorder in susceptible fruit. The disorder varied widely in limes from different groves and developed most rapidly during the initial 7 days in storage at 50° F. (MQ 2-64)

4. Factors Affecting Volatile Production by Oranges. The effects of temperature and injury on volatiles emanating from whole Valencia oranges were studied. Volatiles emanating from injured and uninjured Valencias increase with increasing temperature. Volatiles emanating from injured oranges were nearly 75 times as great as those from uninjured fruit. Ethylene treatment increased the production of volatiles by lemons. (MQ 3-89)

F. Postharvest disease control

1. Control of Decay of Florida Citrus Fruit. Five new fungicides were evaluated for control of citrus decay. Four were ineffective. Two-amino-butane (2-AB) base, when used as a fumigant at 12 mg./l. (70°-90° F.), was superior to standard treatments. When applied as a 1% dip or spray treatment, 2-AB phosphate was consistently more effective than the standard 2-AB carbonate. Thiabendazole or hot water + 2-AB carbonate + 2-4,D were more effective during storage than 8 other prestorage treatments for tangelos and Temple oranges.

Decay of specialty citrus hybrids (Lee, Nova, and Page) was directly related to degreening time. Excessive stem-end rot and anthracnose decay developed in fruit degreened for 45 hours or more. A biphenyl-resistant strain of Penicillium digitatum was isolated for the first time in Florida from natural sources. (MQ 2-65)

2. Materials Affecting Spore Germination and Growth of Decay Organisms. Octanal inhibited germination of spores of Penicillium digitatum, Phomopsis citri, and Diplodia natalensis at a concentration of .04 mg/l. Other aldehydes were less effective, and corresponding alcohols were not inhibitory. Terpenes and esters were not inhibitory. Twenty-five volatile components of citrus fruits were tested. Butanal was more effective than any other aldehyde tested in fumigation tests with inoculated oranges. (MQ 2-100)

3. Effects of Controlled Atmospheres on Growth of Citrus Decay Organisms.

Reducing the concentration of oxygen in static or flowing atmospheres severely influenced growth rates of Penicillium digitatum in artificial media, and decay rates of inoculated lemons and Valencia oranges. As oxygen was reduced to 2% growth rates and decay rates were reduced slightly, but between 1% and 0% oxygen was very limiting. At 1% oxygen, fungus growth and fruit decay were reduced considerably. At 0% oxygen, there was little or no fungus growth or fruit decay apparent. At the 1% and 0% oxygen levels, fungus sporulation was severely restricted. Non-inoculated oranges and lemons developed off-flavors at 1% or lower concentration of oxygen, and these injured fruits were susceptible to secondary decay on later storage in air. (MQ 2-126)

4. New Market Diseases of Navel Orange. A blemish on Navel oranges from California has been observed during the past season which is new to the Chicago laboratory. It is characterized by the protuberance of one or more of the navel convolutions, which are light to dark grayish-brown, hard, dry and rough, and vary from a few millimeters to two centimeters in size. Fifty-two organisms have been isolated from these protuberances. Reinoculation studies with oranges show that 37 out of 47 different isolates can cause decay. None of the 47 organisms caused a protuberance of the navel convolutions when inoculated back into mature oranges. (MQ 2-64)

5. Market Losses in Oranges During Marketing. Average losses over a 5-month period for California Navel oranges in Chicago market were slightly over 2% at each of 3 market stages, wholesale, retail, and consumer. Florida Valencia oranges during a 3-month period showed higher losses at the retail and consumer level but lower losses at wholesale. In the New York City market area average losses of California Navel oranges at wholesale, retail and consumer level were identical to those reported for Chicago. Losses were caused mainly by blue and green molds. (MQ 2-132)

6. Postharvest Diseases of Tropical Fruits. Continuation of this P. L. 480 research in India has resulted in identification and description of numerous diseases which cause market losses in tropical fruits. Additionally 14 fungicides were tested for postharvest application and heat treatments were evaluated for decay control in mangos. Hot water treatments were not successful for bananas because of fruit injury. Determination of optimum amino acid composition of culture media has developed useful information for in-vitro studies of many of the decay organisms. (A7-AMS-6)

7. Antimicrobial Action of Biphenyl. This research, which is done under a P. L. 480 project in Germany, is developing potentially useful information on the mechanisms of the inhibiting action of biphenyl on growth of decay producing organisms. Studies have shown an inhibiting action on respiration and carbohydrate metabolism. Studies with pure enzymes have shown that lactic acid dehydrogenase is inhibited by .07% sodium orthophenylphenate. Biphenyl inhibits the same enzyme in concentrations of 0.5% and higher. (E10-AMS-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Craft, C. C. and S. Norman. 1966. Clean-up and screening of citrus extracts for residues of benzo(a)pyrene and two other polynuclear hydrocarbons. Jour. AOAC 49:695-701. (MQ 2-46)

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AREA 2

DAIRY PRODUCTS - MARKET QUALITY

Problem. Dairy products in marketing channels are subject to deterioration by microbiological action and oxidative processes. In addition, several kinds of insects and mites may contaminate or damage dairy products during storage and distribution. Improved tests for estimating initial quality and information on factors influencing keeping quality would be useful to minimize deterioration in marketing channels. Pasteurized milk invariably spoils within a week or two from bacterial growth in refrigerated storage. Information is required on the source of the spoilage organisms and on how they may be eliminated. Safe and effective methods of preventing or controlling insect and mite infestations are needed. More information is needed on the storage-life of butter and butteroil under various conditions and on the factors which predispose these products to deterioration. Contamination by pesticide residues continues to be a major problem. Simplified methods are needed for detecting such residues in dairy products and also in feeds to facilitate removal of excessively contaminated products from marketing channels.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage-life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

USDA AND COOPERATIVE PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. At Beltsville, Maryland, studies are continuing on improved methods of analysis of feeds and forages for chlorinated pesticide residues (MQ 3-70). Arrangements have been made to obtain butter samples to make a study of the relation of moisture distribution to keeping quality of butter (MQ 3-57). A basic study of heat injury and recovery of bacteria was begun (MQ 3-93). The Federal scientific effort in the Field Crops and Animal Products Research Branch devoted to research in

this program totals 2.0 scientific man-years. The following projects were terminated during this period: Development of objective tests for predicting keeping quality of anhydrous butter (MQ 3-49) and Improved procedures for direct microscopic counting of bacteria in milk (MQ 3-76).

Another program formerly located at Fresno, California, was moved to Madison, Wisconsin, at the beginning of the reporting period. This program involves basic and applied entomological research directed toward the prevention of insect and mite infestation in dairy products. It is carried out in cooperation with the Wisconsin Agricultural Experiment Station. Much of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

A 3-year cooperative agreement (1966-1969) with the University of Wisconsin is concerned with the study of microbial symbionts in selected stored-product insects.

Under a 3-year cooperative agreement (1967-1970), the University of Wisconsin will study the effect of wall coatings on the residual toxicity of insecticides.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, is for a 3-year study, part of which is on the constituents of dairy products that attract mites. It continues until August 1968 and involves P.L. 480 funds with a \$38,622 equivalent in Japanese yen.

The Federal effort in the Stored-Product Insects Research Branch on this program during the reporting period was 1.8 scientist man-years, of which 0.6 was on a contract and 0.2 on a cooperative agreement.

A 2-year research contract under Line Project MQ 1-32(C) with the Stanford Research Institute, Menlo Park, California, was concluded at the end of the reporting period. It achieved its objective to identify and synthesize the natural attractants in the black carpet beetle.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 16.5 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Moisture Distribution in Butter. Arrangements have been made to obtain samples of a number of lots of butter before and after printing to determine the effect of printing on moisture distribution and shelf-life. (MQ 3-57)

2. Chlorinated Pesticide Residues. It is difficult to clean up chlorine pesticide residues in livestock feeds for analysis. Single-step chromatographic procedures proved inadequate for preparing samples for analysis by thin-layer chromatography (TLC). A two-step procedure using successive columns of carbon-celite and partially inactivated Florisil proved very effective with all types of feeds encountered. The carbon-celite procedure was modified for preparing samples for both gas and thin-layer chromatography. Using a 1 g sample of feed, residues can be detected at 0.01 p.p.m. (MQ 3-76)

3. Direct Microscopic Counts. The study of correlations among four direct microscopic counting (DMC) procedures for milk was completed. The DMC stains used were: (a) the Levowitz-Weber methylene blue stain, (b) a modification of (a) incorporating basic fuchsin, (c) an alcohol-acetic acid fixation followed by a periodic acid-bisulfite-toluidine blue stain, (d) an alcohol-acetic acid fixation followed by staining with toluidine blue buffered to pH 4.0. Correlation was highest (0.968) between staining procedure (a) and (d) and lowest (0.854) between (b) and (c). The type of organism inoculated in milk influenced the correlations among the four procedures. The precision of DMC counting was shown to be independent of the staining procedure, but was significantly influenced by the number of microscopic fields counted. (MQ 3-76)

4. Heat Stability of Bacteria. A basic study of the problem of heat resistance and damage of bacteria which constitute the normal spoilage flora of pasteurized milk held at refrigeration temperature was initiated. On the basis of their heat resistance and their pattern of recovery, under the conditions of the experiment, bacteria were separated into various groups; those which will survive the heat treatment (30 minutes at 55° C.), those which will neither survive nor recover, those which will not survive but will recover after various lengths of time in the recovery medium. Preliminary results indicate that the presence of a complex medium (even in dilute concentration) during heat treatment as well as during recovery is necessary for bacteria to recover. (MQ 3-93)

B. Prevention of insect infestation

1. Biological Control. The sex-attractant produced by female black carpet beetles, Attagenus megatoma (formerly called piceus) has been isolated, identified, and synthesized. The compound is trans-3,cis-5-tetradecadienoic acid. Male beetles respond to the synthetic product in the same manner as they do to the females. A trap to be used with the attractant has been built and tested successfully in the laboratory. Large numbers of female Trogoderma inclusum and T. glabrum have been isolated and their sex-attractants are receiving preliminary study. (MQ 1-32(C))

The existence of a potent sex attractant produced by female cigarette beetles has been demonstrated. Experimental procedures developed in the study of the carpet beetle pheromone have been used in this study, with adaptations and additions where necessary. Mass rearing procedures were developed and large numbers of females have been isolated. Preliminary indications are that the attractant is relatively stable and can be stored in a deep freeze. Its volatility is such that both short-pass distillation and thin-layer chromatography can be applied. (Exploratory)

In a detailed anatomical and histological study of the alimentary canal of the carpet beetle Attagenus megatoma, ninety percent of the larvae examined were found to contain intestinal protozoans of the family Actinocephalidae. They are reported to be nonpathogenic but this point is not certain. Their association with the insect is receiving further attention. Preliminary studies were made on the isolation and identification of other micro-organisms associated with several species of dermestids, the Indian-meal moth, and the cigarette beetle. Antimicrobial feeding studies were conducted to develop aposymbiotic individuals and populations. Significant decreases in weight were noted in some tests where sorbic acid was used. (Cooperative Agreement, University of Wisconsin)

An attractant for the cheese mite has been separated from cheddar cheese by steam distillation. It can then be extracted from the distillate with ether and is found in the neutral fraction of the ether extract. (All-MQ-3(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

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Tarassuk, N. P., Abe, N., and Moats, W. A. 1967. The dye binding of milk proteins, USDA Tech. Bul. No. 1369. (MQ 3-14(C))

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AREA 3

DECIDUOUS FRUIT AND TREE NUTS - MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition, these products vary widely at harvest in the characters that determine market acceptance. Practical objective measurements of quality would greatly assist in standardization and grading procedures, and the development of instrumentation for this purpose increases the chance for automatic quality sorting on a commercial basis. Additional information on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting would be useful. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Research must be continued with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits and tree nuts are subject to insect infestation while drying in the field, during storage while they await processing, in the processing plant and in marketing channels until they reach the final consumer. Research is necessary to develop more effective measures for preventing insect infestation all along this line. Emphasis must be given to finding methods that will avoid both insect contamination and pesticide residues.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, entomologists and food technologists. The research includes definition, measurement, and maintenance of quality during the period between harvest and consumption. Locations include Beltsville, Md.; Wenatchee, Wash.; Fresno, Calif.; Raleigh, N. C.; Chicago, Ill.; and Belle Mead, N. J. Cooperative agreements and limited contributed funds are in effect with the California Strawberry Advisory Board. P. L. 480 supported research is underway in Finland on the effects of pesticide sprays on the storage life of certain fruits. Limited support under cooperative agreement is provided for pear studies at Oregon State University and the University of Maryland.

There is also a continuing program headquartered at Fresno, California, where entomologists are engaged in basic and applied research directed toward the prevention and control of insect infestations in dried fruits and in tree nuts after harvest. The work is conducted in cooperation with California State and County agencies and several industry groups. Much of the cross-commodity research at Savannah, Ga., reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dried fruits and tree nuts.

Federal effort in this program totals 20.7 scientist man-years divided as follows: Objective measurement of quality 3.0; quality maintenance in handling and packaging 1.5; quality maintenance in storage 3.0; quality maintenance during transportation 2.0; postharvest physiology 1.0; postharvest disease control 4.2; and prevention of insect infestation 6.0.

Research under P.L. 480 includes a 5-year project in Finland for \$96,441 equivalent, involving the effects of pesticides on storage life and composition of fruits; and a 5-year study in Poland for \$34,967 equivalent, on the ecology of mites attacking dried fruits and herbs.

A 3-year cooperative agreement with the California Department of Agriculture for research to determine the morphological and taxonomic characters of immature stages of Carpophilus continues through June 1970.

Projects terminated during this period included: Film liners for fruit (MQ 2-63), Effects of high nitrogen during simulated transit on fruits, (MQ 2-71), Ozone on fruits (MQ 2-102), and Anthocyanins in cherries (MQ 3-100).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 19.9 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern Apples. At harvest, two different light transmittance signals separated Red Delicious apples into four or five significantly different categories, but only two or three significantly different groups could be detected by the taste panel and objective tests. Preliminary data indicates that the light transmittance signal Δ O.D. 580-640 nm is at least equal to the previously used Δ O.D. 700-740 nm, which is specific for chlorophyll in evaluating quality. (MQ 3-95)

2. Western Apples. Starking Delicious apples sprayed with "Alar" during growth were slightly more acid than check fruit at harvest and after 8 months in storage. Treated fruit averaged about 1 pound firmer at the end of 7 months' storage than the controls, and did not have a typical flavor. There were no consistent differences between Alar-treated and non-treated Golden Delicious apples.

Starking Delicious from an orchard with the lowest foliar nitrogen had the least chlorophyll, highest acidity, and were firmer after storage for 9 months than fruit from 2 other orchards with higher foliar nitrogen. Golden Delicious apples softened most during the first 1 to 2 months in storage. Firmness was inversely related to fruit size at harvest and the differences were

greater with delayed harvest. During storage, firmness declined more rapidly in the small than in the large fruit. Soluble solids were consistently higher in yellow than in green fruit and reached a maximum in the fruit harvested 145 days from bloom. Total acidity decreased 20% between the 145 and 155-day harvests. (MQ 3-95)

B. Quality maintenance in storage

1. CA Storage of Eastern Peaches and Nectarines. Peaches: Storage of firm ripe Loring and Redhaven peaches for 6 or 9 weeks in air at 32° F. was not satisfactory. The fruit developed internal browning and failed to attain acceptable quality when transferred to 65°. Peaches stored in 1% O₂ and 5% CO₂ at 32° for 9 weeks and ripened in air at 65° were of better quality according to taste panelists, than fruit from any other atmosphere and were free of internal browning.

Nectarines: Late Le Grand nectarines responded somewhat the same as the peaches. However, a 21% O₂ - 5% CO₂ atmosphere was about as good a storage atmosphere as the 1% O₂ - 5% CO₂ atmosphere. Lowered O₂ and increased CO₂ concentrations independently reduced development of decay during storage and ripening, but did not control it effectively. Nectarines developed less decay than peaches. (MQ 2-99)

2. CA Storage of Western Nectarines. In tests at Wenatchee, Washington, atmospheres containing 5% CO₂ were the most favorable of 10 different atmospheres tested for holding nectarines at 31° F. The O₂ level within the limits of 1 to 21 percent did not appear to be a critical factor. The desert quality of the fruit in 5% CO₂ in air or in an atmosphere with low levels of O₂ was good after 8 weeks of storage. (MQ 2-99)

3. Storage Life of Apples as Related to Rate of Cooling. Hydrocooling Starking and Golden Delicious apples soon after harvest was not significantly better for prolonging storage life than air-cooling in cold storage rooms in which the fruit was cooled to 32° F. in 3 days or 7 days. At 3 examination periods during up to 8 months' storage at 31°, no consistent differences in flesh firmness, soluble solids, total acid or taste panel evaluations were found between hydrocooled apples and those air-cooled in 3 and 7 days. However, the quality of fruit that required 14 days to cool was lower after each storage period. (MQ 2-127)

4. Season Temperatures as Related to Storage Quality of Pears. Preliminary results of research at Hood River, Oregon, confirm the generally held opinion that Bartlett pears have poorer storage quality when harvested after a cool season (as determined by either minimum or maximum temperatures or by heat units during the 9-week period following full bloom) than when harvested after a warm season. Quality of Bartlett pears harvested at different maturities in 1965 (a warm season) ranged from about 9.5 to 11.5 (on a scale in which 12 represented highest quality). In 1964 and 1966 (cool seasons) quality ranged from about 7.5 to 9.5. Similar differences between seasons was not evident in Anjou pears. (Cooperative Agreement, Oregon State University)

C. Quality maintenance during transportation

1. Domestic Air Shipment of California Strawberries. Strawberries shipped via jet cargo planes from California to eastern markets in the fall of 1966, averaged $16\frac{1}{2}$ hours in transit. Average ambient temperatures ranged from 58° to 68° F., being in the low sixties most of the time. Strawberry temperatures averaged between 41° and 53° F. and gradually rose from shipping point to delivery at the wholesalers. Top layer temperatures averaged about 8° warmer than middle layer temperatures. Sealed, coated pallet covers with dry ice enclosed, produced atmospheres that averaged about 16% CO_2 and 15% O_2 . Berry decay was slightly less in the sealed covers than in the regular or partial covers but the differences were not significant. (MQ 2-83)

2. Export Air Shipment of California Strawberries. Strawberries shipped by air from California to European markets averaged 28.5 hours in transit. About one-half of this time was spent in flight, 42% in airports, and 9% in transit to the airport. Average temperatures of precooled strawberries shipped in fiberboard pallet covers were about 38° F. at origin and ranged from 44° in the middle layer to 57° in the top layer at destination. Sealed polyethylene coated pallet covers with dry ice enclosed averaged about 16% CO_2 and 14% O_2 in transit. Nitrogen-refrigerated airline containers helped maintain initial berry temperatures, but did not reduce the temperatures significantly if the berries were not cool when placed in the container. Atmospheres in the containers ranged from 0.5% O_2 to 12% O_2 ; CO_2 did not accumulate significantly. Decay averaged about 3.0% one day after arrival at European airports, when the berries were shipped in regular fiberboard pallet covers. It was about one-half as much when coated covers were used to produce high CO_2 atmospheres. Fewer soft berries developed in the coated covers than in the regular covers or the nitrogen-refrigerated containers. (MQ 2-83)

3. Rail Shipments of California Strawberries. Palletized strawberries in mixed loads with lettuce were shipped in mechanically refrigerated cars via freight service from California to New York. Temperatures in the centers of pallets averaged about 7° F. above the thermostat settings (34° or 36°). Heavy polyethylene covers over the pallets did not affect transit temperatures but caused injurious atmosphere modification when used in combination with dry ice or "Tectrol" atmospheres (10% CO_2 - 5% O_2 initially). Heat-pasteurized berries shipped in a modified atmosphere had no decay on arrival, and substantially less decay than the untreated berries after 1 and 2 days at 60° F. (MQ 2-83)

D. Postharvest physiology

1. Scald Control for Eastern Apples. New commercially available diphenylamine liquid concentrates were as effective in controlling scald on Stayman, Red Delicious, and Rome Beauty apples during 6 months' storage at 32° F. as the standard 83% wettable powder formulation. Ethoxyquin was as good as diphenylamine for scald control on these varieties but caused some slight calyx burning on Rome. A 30-second dip in 130° water continued to give good

scald protection on Stayman but for Delicious 5 minutes in 120° water gave better scald control and was safer than the shorter dip. Hot-water treatments markedly reduced scald on Rome apples but some fruit usually was injured. Treating apples in a microwave oven for 10-30 seconds gave little scald control and caused some core area desiccation. (MQ 2-91)

2. Scald Control for Western Apples and Pears. Green and yellow Golden Delicious, Red Delicious and Winesap apples were packed with wraps with and without chemical scald inhibitors. The best scald control and least injury on Golden Delicious was obtained with ethoxyquin treated wraps. Red Delicious and Winesap apples responded best to a DPA wrap. Red Delicious apples harvested early developed more than 25% scald regardless of treatment, but early- and late-harvested Golden Delicious both responded well to the ethoxyquin wrap. Anjou pear scald was controlled best with a dip of ethoxyquin plus tutane. Wraps without incorporated ethoxyquin were ineffective.

Red Delicious apples from an early harvest, waxed shortly after picking, developed severe scald during storage. Inclusion of diphenylamine (DPA) in the wax did not reduce scald. Waxing Golden Delicious apples reduced scald development approximately the same amount oil wraps did, but not enough for commercial control. The inclusion of scald inhibitors, DPA, and ethoxyquin in the wax did not improve scald control. DPA caused a surface discoloration which was similar, but not identical to typical scald. Wax applied 4 days after Anjou pears were harvested, increased scald on fruit stored for 6 months. Inclusion of Stop Scald (ethoxyquin) in the wax reduced scald development only slightly. (MQ 2-91)

3. Effects of Pesticides on Composition of Fruits. The postharvest application of CIPC did not have any measurable effect upon the concentration of ascorbic acid, organic acids, amino acids or pectic substances of apples and strawberries while stored at 5° or 10° C. Respiratory activity of the fruit was also not different from untreated fruit. (E8-AMS-6)

E. Postharvest disease control

1. Stem-end Decay in Pears. Treating Anjou pears in water at 130° F. for 3 minutes reduced stem decay but caused severe injury. There were 4 times as many colonies of P. expansum in cultures from the stems of pears run over the line in a commercial packinghouse as in those from fruit that had not gone over the line. This suggests that much of the contamination occurs during packing operations. Four fungicides were tested for control of stem decay. Thiabendazole (1000 ppm) and captan at 1200 ppm reduced infection but did not provide adequate control. (MQ 2-124)

2. California Grapes. After 5½ months' storage at 32° F. Emperor grapes that were hydrocooled with 38° F. water and fumigated with SO₂ for 2 minutes were cleaner, brighter, and had more attractive stems than those that were cooled in air and fumigated with 1% SO₂ for 20 minutes. The incidence of decay was low in all lots. (MQ 2-101)

3. Composition as Related to Decay in Blueberries. Blueberries from selections high in acid developed about one-third as much decay as fruit from selections low in acid. No obvious differences in decay were associated with sugar content. Wolcott and Jersey varieties of blueberries with high anthocyanin content developed more decay than those with smaller amounts. (MQ 2-94)

4. Decay Control for Strawberries. Exposure of strawberries to temperatures between 105° and 108° F. for 45 minutes with air flows above 4 cfm/lb of fruit reduced decay by about 80% when the berries were held subsequently for 3 days. Careful control of air flow, as well as temperature and exposure time, is necessary to control decay uniformly. (MQ 2-83)

5. Heat Treatment of Peaches. Dips of 30 seconds in 0.5% tutane (2-amino-butane) reduced brown rot in inoculated peaches as effectively as hot water or hot air treatments. They were not as effective for rhizopus decay control. Similar dips in 0.5% potassium azide reduced both brown rot and rhizopus about 50%. The gas, isomaltol, was ineffective against both decays and caused fruit injury. Two and one half minute dips in 125° F. water or 30 minute exposure to 125° air of 90% relative humidity reduced both decays about 80%. Exposure to 125° air of 50% relative humidity did not reduce either decay appreciably. Germination of swollen monilinia and rhizopus spores and growth from germinated spores in heated broth was prevented at temperatures and exposure times which did not affect the germination of dormant spores. With very short exposures in heated broth extreme variation occurs in the percentage of spores surviving the treatment. (MQ 2-104)

6. Heat Treatment of Figs. Black Mission figs were heated to about 115° F. for 30 to 60 minutes at air flows ranging from 25 to 32 cfm/lb of fruit. In all combinations tested so far surface molds were reduced by about 80% during 5 days at 64°. No change in flavor could be detected in taste tests. Heating Kadota figs for 30 minutes at 118° reduced surface mold by about 70% and almost eliminated rhizopus decay. Souring was not affected. (MQ 2-114)

7. Ozone Treatment of Fruits. Ozone treatment (0.5 ppm) during storage at 35° F. had no influence on subsequent shelf life of peaches, strawberries, or blueberries held in air for 4 days at 70°. The size of fungal nests was somewhat reduced in peaches and strawberries held in ozone at 60° but low temperature was a more effective control. Ozone had no effect on decay of cantaloups held for 7 days with 0.5 ppm ozone at 45° followed by 5 days at 60°. Ozone inhibited surface mold growth but did not reduce botrytis rot on grapes during 6 to 7 days at 60° in 0.5 ppm ozone. (MQ 2-102)

8. Effects of Atmosphere Modification on Growth of Certain Fungi. Atmospheres containing only 0.25% oxygen reduced spore germination in descending order of Rhizopus stolonifer, Cladosporium herbarium, Alternaria tenuis, and Botrytis cinerea. While Rhizopus spores were most sensitive to low oxygen its mycelia grew better under lower oxygen tensions than mycelia of the other fungi. Growth of Rhizopus on inoculated strawberries in atmospheres of 21,

1, 0.5, 0.25 and zero percent oxygen decreased linearly with decreasing oxygen concentration. Growth in 1% O₂ averaged 50% of that in normal air. In 0% oxygen, although no growth occurred, there was softening of tissues around the infected area. Crude extracts of infected berries contained pectic-degrading enzymes polygalacturonase (PG) and pectin methylesterase (PME) as well as cellulase. Activities of these enzymes were directly related to the amount of growth of the fungus in each atmosphere. Rhizopus grew and produced enzymes under near-anaerobic conditions on glucose medium but not on pectin medium. In the latter, production was repressed by addition of glucose to the medium. Carbon dioxide, when added to low-oxygen atmospheres, further depressed the growth of Rhizopus stolonifer. (MQ 2-112)

9. Enzyme Relationships in Penicillium Strains. On a defined medium with different sources of organic carbon, virulent and avirulent strains of Penicillium expansum, P. digitatum and P. italicum produced endo- and exopolygalacturonase but no detectable pectin methylesterase or pectin lyase. Extracts from oranges infected with P. italicum or P. digitatum and from apples with P. expansum also contained the polygalacturonases. Extracts from sound fruits did not contain polygalacturonases. In vertical starch-gel zone electrophoresis of culture filtrates and diseased tissue extracts, the number, location, electrophoretic mobility, and relative activity at sites of endo- or exopolygalacturonase activity depended on the fungus species, virulence of the strain, organic carbon source, and gel pH. (MQ 2-96)

10. Proteolytic Enzyme Activity by Fungi. Botryosphaeria ribis (and 10 other fungi, in appropriate hosts) produced protease in infected apples. Because enzymes are often inactivated by host polyphenols a method is being developed to vacuum-infiltrate a solution of polyethylene glycol into diseased B. ribis-apple tissue to inactivate polyphenols and increase enzyme recovery. (MQ 2-97)

11. Fungicides for Control of Decay in Apples and Pears. Delicious, Rome, and Winesap apples were treated with dips of sodium-o-phenylphenate (SOPP), 2-aminobutane (2AB), diphenylamine (DPA) and a mixture of 2AB and DPA. SOPP was most effective in controlling decay followed in order by 2AB + DPA, 2AB, and DPA. On Golden Delicious the treatments containing DPA were less acceptable than on the other varieties due to chemical injury caused by DPA. Anjou pears stored for 7 months in polyethylene box liners had the most decay when treated with SOPP and the least decay with captan dip. Germination of rhizopus spores soaked for 1 hour in 0.5 percent SOPP was only slightly inhibited if the spores were rinsed with clear water after treatment. (MQ 2-125)

12. Effects of Vapor Heat on Fungus Spores. Ungerminated spores of 4 decay causing fungi were treated with moisture-saturated hot air at 110° F. under the same conditions used for heat treating flowers and strawberries. Times required to kill half the spores (LD₅₀) were 68 minutes for Alternaria tenuis, 33 minutes for Rhizopus stolonifer, 16 minutes for Botrytis cinerea, and 12.5 minutes for Cladosporium herbarium. If Botrytis spores were suspended in water for 6 hours prior to treatment to induce germination, survival was reduced 50% (Exploratory)

13. Market Losses in Apples. In the New York City market, losses in Eastern and Western Red Delicious apples was slightly less than 1% at wholesale, about the same at retail and about 2.5% at the consumer level. Losses averaged somewhat higher at wholesale and retail markets but lower in consumer channels in Chicago. Losses were principally from internal breakdown, bruises, and decay. (MQ 2-132)

14. Market Losses in Peaches. Total losses in peaches in the market averaged about 14% in both New York City and Chicago. Losses at the consumer level were generally greatest. Most of the wastage resulted from development of brown rot as the fruit ripened. (MQ 2-132)

15. Market Losses in California Strawberries. Total market losses were rather high (average about 45%) with losses increasing at each step from wholesale to the consumer. Most of the losses were due to decay. (MQ 2-132)

F. Prevention of insect infestation

1. Biological Control. Pathogens in stored-product insects have received very little attention until new studies were initiated during this reporting period. Many species of protozoan pathogens have been found in a variety of stored-product insects from laboratory cultures and field collections. Most of them have not been reported previously from stored-product insects and represent undescribed species. A granulosis virus was isolated from two laboratory cultures of the Indian-meal moth. Several field populations of this moth were found infected with Bacillus thuringiensis. All the pathogens found were readily transmitted perorally. All but one were highly pathogenic. Larvae that acquired acute infections died before pupating. Laboratory cultures of insects infected with many of these pathogens have been established for future studies.

The morphology and developmental cycle were described for a previously unknown species of Nosema from the Indian-meal moth. The pathogen was found to invade a variety of tissues and organs. Larvae were readily infected perorally and those with acute infections usually died before pupating. The pathogen invaded developing eggs. Adults harboring latent infections transmitted the pathogen through eggs. Tests with other species of insects indicate a limited host specificity. A manuscript describing the new species of pathogen and the related findings has been sent to a journal for publication. (Exploratory)

2. Biology and Ecology. It was discovered that many infestations believed to be the saw-toothed grain beetle, Oryzaephilus surinamensis (L.) are actually the closely related merchant beetle, O. mercator (Fauvel). This raises many questions that need to be answered about comparative biology, ecology, habits, behavior, nutritional requirements, and food preferences. In comparative studies of the two species under constant conditions of 86° F., 50% relative humidity and low light intensity, each developed best on rolled oats plus yeast, next best on almonds, and rather poorly on raisins. Neither species did well on prunes where only a few saw-toothed grain beetles completed development from egg to adult and none of the merchant beetles developed to the

pupal stage. The saw-toothed grain beetle did better on raisins than did the merchant grain beetle, and the latter did better on almonds. Records are being accumulated on temperature and humidity ranges in several storage areas for dried fruits and tree nuts, and in the stored commodities. This information will serve as a foundation for future ecological studies. (Exploratory)

Adult females of some species of the dermestid genus Trogoderma are extremely difficult to identify. To discover new identification characters, 7 species were cultured and specimens of 9 others were obtained for study. About 700 slides were prepared for study of internal characters and some 600 adults were pinned. The significant discovery of a character to identify female khapra beetles was published. It was also found that the shape and size of internal structures of the female reproductive system permit identification of other species. Drawings are being made and this information will be published after further study. A manuscript has been written to describe the technique for slide preparation. A series of color photographs has been made to show the elytral color patterns of the various species. (Coop. Agreement, California Department of Agriculture)

A comparison of the digestive enzymes, development, and egg laying of four species of mites has helped to explain their food requirements. Acarus siro fed and developed on the hyphae of many species of molds but fecundity was usually low. It digested starch very poorly and was adapted to foods rich in fats. This was reflected by low amylase and high lipase recoveries from the mites. A. farris digested starch and fat only in small amounts but fed much better on microorganisms as a single food. Tyrophagus putrescentiae readily fed on all microorganisms tested, with high fecundity and low mortality. It also digested starch rather well. Rhizoglyphus echinopus fed on many microorganisms but fecundity was low and it digested neither starch nor fat very well. (E21-MQ-1(a))

Studies thus far indicate hypopus formation is more related to population density and kind of food than to temperature or humidity. Appearance of hypopi is more common in some populations than in others of the same species. Humidity affects the transformation of hypopi to tritonymphs. Histological and anatomical studies of hypopi of Acarus farris show this is not a regressive stage. It is anatomically and functionally adapted to survive unfavorable conditions and to disseminate the species. It has a thick cuticle to resist drying out and has a special complex of muscles for the sucking disc and dorsal side of the body, enabling it to attach to other animals or moving objects. There is a striking difference in the alimentary canal, where the pharynx, esophagus, and stomach are small. The walls of the stomach resemble those of the esophagus, side protuberances are small, and anterior glands are absent (E21-MQ-1(a))

3. Improved Pesticidal Control. Results of small scale tests with malathion spray and dust treatments for one year on figs and two years on raisins indicate that 5 to 20 ppm in dust form and 50 ppm as a spray show sufficient promise to carry them into larger scale tests. (MQ 1-15)

Equipment for applying protective sprays to grain is not suitable for treating dried fruits or tree nuts. A new machine was designed, constructed, and tested. It can be adjusted to apply a wide range of dosages, fits in with industrial handling conditions, and appears to perform satisfactorily. Shelled almonds were treated with this machine at 3, 8, 12, and 16 ppm for a small-bin storage test. Treated almonds subjected to taste panel tests showed no significant change in flavor or odor. A preliminary test indicates that blanching to remove the seed coat eliminates a large amount of the malathion residue. In another small-bin test malathion as a dust at 10 and 20 ppm and as a spray at 30 and 50 ppm gave good protection through 1 year of storage. (MQ 1-27)

The vapor generator developed by the Savannah laboratory for dispensing dichlorvos was operated August through October, the period when vinegar flies and dried fruit beetles are most numerous, in a wine cellar with 268,495 cu. ft. of air space. High humidity rapidly decreased vapor concentrations but the degree of control was promising. A single exploratory test was made to compare the rate of decrease in air concentration of dichlorvos after a vapor generator treatment and a thermal aerosol treatment. After one-half hour, there was a 10% loss from the vapor treatment and 80% from the aerosol, and at the end of an hour the losses were 52% and 90% respectively. Samples of sherry and tokay wines exposed in open beakers to 3 hours of vapor generator operation contained less than 0.03 ppm of dichlorvos. A taste panel could detect no off flavor. (MQ 1-34)

A psocid as yet unidentified was found to cause high mortality of the Indian-meal moth in a laboratory room at Fresno. It consumed eggs and fed some on dead larvae but live 1st instar larvae were not eaten.

A study has begun to determine the effect of various concentrations of malathion on the oviposition cycle of the Indian-meal moth. At one concentration the peak of oviposition occurred at 9 p.m. Pacific Standard Time for both treated and untreated moths. Treated moths laid more eggs the first day than did untreated ones but the viability was low. Treated moths produced fewer eggs and offspring than did untreated moths. When last instar larvae were treated with malathion, swelling of the thorax and abdomen was observed in some and an occasional dead larva was found to have adult as well as larval characteristics. This information was given to an insect physiologist at the Savannah laboratory for further investigation. (Exploratory)

About 10 million malathion-treated paper raisin drying trays were used by industry for the 1966 crop, the first year they were commercially available. The trays were to have been treated with 100 mg. of malathion per sq. ft. They contained an average of 60 mg./sq. ft. when placed in the vineyards. Raisins dried on the trays contained about 3.5 ppm of malathion, well within the 8 ppm tolerance and enough to protect the raisins against insects during storage prior to processing. The industry was enthusiastic about the performance of the trays. There are plans to have 22-24 million trays available for the 1967 crop. (MQ 1-34)

4. Insect-Resistant Packaging. Some tests are completed and others have been in progress at least 3 months to evaluate the insect resistance of packages in current use for raisins, figs, prunes, peaches, apricots, and mixed dried fruits. The 941 packages in the tests comprise 19 series of cartons and 17 series of visipacks or flexible pouches. They are exposed in a laboratory storage room to a heavy infestation of several species of insects that attack dried fruits. A plastic cup with heavy polyethylene cover, a package not used extensively, was the only type not infested after 6 months in the exposure room. All other types of packages were at least 33% infested within 3 months. Insects attacked the packaged raisins and figs more than the other fruits. The most resistant of the cartons were those with a foil overwrap. The best of the pouches was a polypropylene-cellophane combination. The heavier polyethylene-cellophane combinations provided some insect resistance. In another series of tests lasting 12 months, plain kraft board gave an average of 2.2 months of protection against infestation, board plus 1-mil polyurethane 3.8, board plus 1-mil nylon 5.2, board plus 1-mil polyethylene 6.2, and board plus 1-mil polycarbonate 6.4. A laminate of 0.0035 foil between two layers of 1-mil polyethylene gave complete protection in all 5 replicates. (MQ 1-22)

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AREA 4

GRAIN - MARKET QUALITY

Problem. Grain and cereal products are subject to damage, contamination, or deterioration in quality while in the marketing channels. These adverse effects may result from normal metabolic changes, the action of microorganisms, the attack of one or more of some 50 different kinds of common stored-product insects, or pesticide residues left by control measures applied against the insect pests. The damage may be conspicuously evident or insidiously hidden; may result in destruction of nutrient values or the presence of undesirable substances in food and feed; or insects may render products aesthetically unacceptable. Such deterioration affects the grade and price received, and end use, the wholesomeness of the product, and the competitive position of U. S. commodities in the world market. Research is needed to protect this multibillion dollar crop from outright destruction, evident deterioration, and hidden damage, especially as the need for food and animal feed becomes more critical throughout the world. The standard procedures that were formerly acceptable are becoming obsolete as a critical market demands higher quality, as international pesticide residue tolerances are in the process of being adopted, and as supply lines lengthen through overseas shipment in a worldwide distribution pattern. New methods of protection against insects and disease, of identifying and measuring quality changes, and means of maintaining quality over longer periods of time and under adverse conditions are some of the problems requiring attention.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists, engineers, and plant pathologists in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Maryland and also by contract with the University of Arkansas, Fayetteville, Arkansas and by cooperative agreement with Purdue University, Lafayette, Indiana and the University of Missouri, Columbia, Missouri and a grant with the University of Minnesota.

The Field Crops & Animal Products Research Branch Federal scientific effort in this area totals 18.7 scientist man years: quality evaluation 16.7, and quality maintenance 2.0.

PL 480 projects include a grant to the Institute for Cereals, Flour and Bread, TNO, Wageningen, Holland, providing for the development of simple, reliable and accurate tests to determine relative hardness of wheat for the

purpose of devising a system of classifying wheat for use in official grading and inspection. Its duration is for 4 years (1965-69) and involves \$70,670 equivalent in Dutch guilders.

A grant to the Instituto Nacional de Investigaciones Agronomicas, Madrid, Spain, provides for a study to develop and evaluate equipment and methods for determining the proportions of durum (semolina) and common wheat (farina) in macaroni and spaghetti products. Its duration is for 5 years (1964-69) and involves \$43,563 equivalent in Spanish pesetas.

There is also a continuing Department program involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels. The research is conducted at Manhattan, Kansas and at Tifton and Savannah, Georgia, in cooperation with the respective State Agricultural Experiment Stations, the Transportation & Facilities Research Division, the Agricultural Stabilization & Conservation Service, farmers' cooperatives, the Association of Operative Millers, the American Corn Millers Federation and other industry groups. The Commodity Credit Corporation makes available various commodities and storage facilities for experimental use, thus greatly facilitating the program. There is also overall cooperation with several State Agricultural Experiment Stations through participation in Regional Project WM-52 "Maintaining marketability of stored grain and cereal products through insect control by methods leaving no, or a minimum of, pesticide residues."

There are four cooperative agreements with the Kansas State University as follows: (1) a 3-year study for research on the biology and behavior of the Angoumois grain moth, through December 1968, (2) a 2-year study of insect infestation in bulgur and methods for prevention, to April 1969, (3) a 3-year study of the physiology of water balance in the yellow meal worm, to June 1970, and (4) a 2-year study of the fate of malathion residues on grain sorghum, to June 1969.

A 2-year cooperative agreement with the University of Wisconsin continues until April 1969 for a study of the bacteria occurring in the alimentary canals of the gramary weevil and the lesser meal worm.

A 2-year grant to the California State College of Los Angeles continues until June 1969 for research on the effects of grain sorghum varieties on the development of two species of rice weevils.

A 1-year cooperative agreement developed jointly by the Market Quality and Entomology Research Divisions with the University of Maryland continues until June 1968 for research on the biology and ecology of the lesser meal worm in relation to transmission of leukosis to chickens.

A grant to the Indian Agricultural Research Institute, New Delhi, India, for a 3-year study of varietal resistance of wheat kernels to damage by the rice weevil and lesser grain borer continues until February 1968 and involves PL 480 funds with a \$15,146 equivalent in Indian rupees.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, for a 3-year study, part of which is on the constituents of wheat that attract insects, continues until August 1968 and involves PL 480 funds with a \$38,622 equivalent in Japanese yen.

A grant to the Maharaja Sayajirao University of Baroda in India for a 5-year basic research study on the physiology of fat metabolism in relation to diapause in the khapra beetle continues until January 1970 and involves PL 480 funds with a \$33,907 equivalent in Indian rupees.

A grant to the University of Helsinki in Finland for a 5-year study on the effects of pesticides on plant commodities, part of which deals with malathion on wheat, continues until December 1969 and involves PL 480 funds with a \$96,441 equivalent in new Finnish finnmaks.

A grant to the National Botanic Gardens, Lucknow, India, for a 5-year study on plant extracts and isolates having pesticidal properties continues until December 1971 and involves PL 480 funds with a \$63,506 equivalent in Indian rupees.

A grant to the Hebrew University, Jerusalem, Israel, for a 3-year study on pheromones produced by the khapra beetle continues until March 1970 and involves PL 480 funds with a \$96,258 equivalent in Israeli pounds.

A grant to the University of Zagreb in Yugoslavia for a 5-year study of non-pesticidal control measures for stored-product insects continues until April 1972 and involves PL 480 funds with an \$84,154 equivalent in new Yugoslav dinars.

The Federal Stored-Product Insects Research Branch effort on the prevention of insect infestation was 7.8 scientist man-years, of which 0.2 was under a cooperative agreement. Much of the cross-commodity research reported in Area 13 "Insect Control in Marketing Channels," is also applicable to the problems in grain.

PL 480 project S9-AMS-6(a), a study in Uruguay on hermetic storage of corn, was terminated at the end of the 5-year grant period.

PL 480 project A10-AMS-4(a), a study in Israel on the effect of ethylene dibromide fumigant on farm animals, was terminated at the end of the 5-year grant period.

PL 480 project A10-AMS-11(k), a study in Israel on the biology of the khapra beetle, was terminated at the end of the 5-year grant period.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 20.4 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

1. Flour-Yielding Capacity of Wheat. The relation of hardness measurements to the milling quality of wheat is being investigated, but no conclusions can be drawn at this time.

The curves from the Hardness Tester denote the soft or hard characteristics of the wheat. The hard red winter wheats produce higher peak values than do the soft red winter wheats. Peak values within the wheat class indicate the degree of hardness or softness. Hard red winter wheats ranged from 425 to 610 Brabender units. Soft red winter wheats ranged from 335 to 535 Brabender units. Increased moisture content was found to decrease the peak value and increase the curve length. If the samples are tested between 8 and 11% moisture, the effect of moisture content is minimized and the curves can be compared.

The effect of kernel size on the hardness measurement was also studied. Samples of each class of wheat were separated into three kernel sizes by sieving. The small kernels produced lower peak values and slightly longer curves. (MQ 3-36)

2. The Effect of Stinkbug Damage on Soybean Quality. Oil content of heavily damaged soybeans averaged a fraction of a percent lower than that of slightly damaged soybeans but protein content in the more heavily damaged beans was a little higher. After storage for 6½ months, soybeans ranging in moisture content from 10 to 14% averaged 0.42% lower in oil content and 22.84% higher in fat acidity. Protein content decreased by 0.42%. Damaged soybeans stored for long periods undergo greater increases in fat acidity than undamaged beans. (MQ 3-65)

3. Identification of Storage Fungi. The Biospect recording spectrophotometer was adapted to record reflectance measurements (at 350 to 850 mμ) of spores deposited on filter paper by using glass fiber optics and a special sample holder. By this means, 12 species of the fungus, Aspergillus, were identified according to reflectance characteristics of their spores. (MQ 3-66(Rev.))

4. Detection of Mixed Corn. A method has been developed for detecting lots of corn in which high-moisture corn has been mixed with low-moisture corn (usually artificially dried and often heat damaged). The method involves determining the moisture content of individual kernels in a sample. There is a greater range of moisture content of kernels in a mixture. (MQ 3-78)

5. Quality Evaluation of All-Purpose Flour. This study covered 26 samples of all-purpose flours delivered east of the Mississippi River. Comparisons of the following analyses were made: Amylograph versus falling number values; falling number versus diastatic activity (maltose); falling number versus loaf volume; loaf volume versus diastatic activity (maltose); falling number versus cookie factor.

The highest degree of correlation was found between (1) amylograph values and falling numbers (0.921), and (2) the falling number and diastatic activity (maltose) (0.893). None of the other relationships were significant. Both of these tests are measures of alpha amylase activity but by somewhat different techniques.

The all-purpose flours were studied also for their gravymaking properties. The MacMichael Viscosimeter ranked the flour for gravymaking in the same order as the falling number test and amylograph with few exceptions. (MQ 3-79)

6. Sampling Research. Three diverter-type mechanical samplers were installed and tested under conditions simulating country elevator operations. Two grain flow rates, two spout slopes, three sampler locations and four levels of homogeneity were studied. Performance of the three mechanical devices and the pelican were compared using wheat containing known percentages of corn and screenings. Component levels exceeding normal levels found in market channels were used to provide a challenge for the sampling devices.

In overall performance, the three mechanical samplers did not differ significantly. They were not biased by flow rate, spout angle, or position along the spout within the conditions of the tests. The pelican performed as well as the mechanical devices except it was slightly more variable.

Handling during the testing procedure caused a rapid increase in the homogeneity of layered grain but did not result in a mixture approaching complete homogeneity.

Sampling research was performed at Minneapolis, Denver and Omaha on hopper car quantities of corn, wheat and soybeans handled at flow rates normally used when loading hopper cars. The grain was also sampled while at rest in covered hopper cars, using three types of probes.

When sampling the same grain more accurate and less variable samples were obtained with the mechanical sampler than with probes. This was true for all three kinds of grain and for diverter slot widths of 0.75 inch and 100 feet per minute velocity across the grain stream. Diverter velocities were increased up to 200 feet per minute without significant loss in performance; however, a decrease in slot width from 0.75 to 0.50 inch showed a significant decrease in performance when sampling soybeans containing 5% of weed seeds as the additive.

Research on grain velocity effects at the diverter of mechanical samplers was conducted in a commercial elevator at Minneapolis. Lots of both fragile corn and tough wheat were sampled after vertical free falls of 1 foot, 50 feet and 90 feet. There was no measurable increase in broken corn in the sample after 1 foot of free fall but at 50 and 90 feet the increases were highly significant. Wheat samples were not significantly different at the three sampling locations. (MQ 3-85(C))

7. Automatic Moisture Meter. A 2-year contract was let to develop an automatic moisture instrument which will give the average moisture content as well as the moisture range in the grain sample. (MQ 3-102(C))

8. Optical Characteristics of Grains. Investigations designed to establish the feasibility of using optical characteristics for identifying specific grains, weeds and foreign materials in a grain sample have been started under a 2-year contract. (MQ 3-105(C))

9. Automatic Test Weight Device. An automatic test weight device is being developed under a 1-year contract. (MQ 3-103(C))

10. Isolating Germ of Grains. Research to develop a method and to design equipment for isolating and concentrating the germ of grains was initiated under research contract. (MQ 3-101(C))

11. Sound Grain Determination. Under contract, work has been started in an attempt to develop procedures and methods for objectively determining the percentage sound grain in a sample. (MQ 3-104(C))

12. Kernel Hardness of Wheat. The ability to differentiate between soft and hard wheats (in hardness) seemed to be greatest when a particle size sieving test was used and least when a Smetar penetrometer was used. Since moisture content and kernel size are important factors in degree of hardness, samples of wheats, of different kernel size and varying moisture contents, are being studied to determine how the various test methods respond to these variations. (E19-MQ-1(a))

13. Macaroni and Spaghetti Products. The presence of sitosteryl palmitate, determined by a modification of the Matweef method, has not shown very promising results for measuring the different proportions of common (Triticum aestivum) wheat and durum (Triticum durum) wheat flours in macaroni products. Studies on the lipids, proteins and lipoproteins have been undertaken to obtain a better differentiation between the two types of wheat. (E25-AMS-7)

B. Quality Maintenance in Storage

1. Changes in Wheat Due to Insecticides. Wheats treated with Cab-o-sil, Silica Aerogel 68, Perma Guard and Kenite showed no further decreases in test weight per bushel and no change in the yield of flour as compared with the untreated wheat when storage period was extended another year. Malathion-

treated wheat did not change in test weight or yield of flour. The different dusts or liquid insecticide materials appear to have no effect on the fat content of the treated samples. In the third year of storage, fat acidity increased in both control and insecticide-treated wheats, with changes averaging higher than in any one year's tests. Diastatic activity (maltose) increased in all the wheats except the Kenite-treated sample which remained relatively constant. The mixing peak by the farinograph in the physical dough tests remained relatively unchanged along with the absorption for the control and insecticide-treated samples. The hot breads from both the control and treated wheats had a stale odor. (MQ 2-70)

2. Quality Changes Due to Fumigation. A cooperative study with the Human Nutrition Research Division on the quality changes in wheat due to fumigation and storage is in progress. Two controls (outside, held at ambient temperatures, and cold, held at 32°F.) and three fumigated wheat samples treated with (1) phosphine, (2) methyl bromide, and (3) three parts of ethylene dichloride plus one part carbon tetrachloride comprise the samples being studied.

The results of chemical and milling tests indicate that the three fumigated wheats were not materially different in any one of the quality factors from those of the outside control or the cold control samples. There were some minor decreases in sedimentation values for each of the lots of the controls and treated wheats. It is known, however, that sedimentation values generally decrease during storage of normal wheat.

There were no important changes in the physical dough tests for the samples.

Averages of the quality characteristics of triplicate bakings for the various testing periods show no important changes between the controls and the fumigated wheats. Sensory examinations were made of the bread baked from the controls and fumigated wheats at the time the loaves were taken from the oven. The hot breads baked from the fumigated samples were found to be normal in odor and similar to the bread baked from the control samples. (HN 1-22)

3. Quality Changes Due to Insect-Resistant Cotton Bags. Chemical and baking tests were carried out on samples of regular cornmeal (with germ), degermed cornmeal and all-purpose flour in cotton and other various types of bags treated with different dosages of an insect-resistant material, pyrethrum-piperonyl butoxide and stored in an insect exposure area. Untreated samples, not stored in insect exposure area, were included as controls.

Chemical analyses of two samples of all-purpose flour both stored in the same type of cotton bags without liners indicate that the lot with the high insecticide treatment had about three times more residue left in the commodity than the other lot.

The only difference in the analysis between the samples was in the bread crumb grain which was materially better for the high residue sample. Significantly higher fat acidity values, loaf volumes and bread crumb grain were found in the high residue sample as compared with the control sample. Flour in the other three bag types (two cotton bags with waxed Kraft paper liners, one low in commodity residue and the other residue free, and paper bag with no residue in commodity) increased significantly in fat acidity during storage compared with the control sample. Other important differences were increases in loaf volume for the cotton bags with waxed paper liners (low residue in commodity) and changes in loaf volume, bread color and grain for the untreated cotton bags residue free with waxed paper liners.

Cotton bags without liners, in which two types of cornmeals were stored, received high and low dosages of insecticide material resulting in high and low residue content in the meal. The samples of low residue content developed much higher fat acidities than samples of higher residue content similarly stored.

There were progressive increases in fat acidity values for the degermed cornmeal stored in the other bag types, i. e., treated cotton bags with waxed paper liners, paper, and untreated cotton bags with waxed paper liners. The first two bag types were treated with medium and low dosages of insecticide material, respectively, while the third bag type had none. No differences were found in fat acidity values for regular cornmeal in these same three bag types. The degermed cornmeal produced higher fat acidities than the regular cornmeal even though it was lower in fat content. The finer granulation of the degermed meal may be responsible. (MQ 1-36)

C. Prevention of Insect Infestation

1. Biological and Physical Control. After 36 months of a long-term storage test with shelled corn in 500-bushel bins in Georgia none of two diatomaceous earths, two silica aerogels, or a malathion treatment was any longer effective. There was a high level of insect infestation in probe samples from all five bins of each treatment. When the bins were unloaded after 42 months of storage representative samples of corn were taken from the grain stream for insect counts, which were lower than those from the probe samples at 36 months. The malathion treatment averaged 24.4 live insects per 1,000 grams. The lowest inert dust was a silica aerogel with 49.6 and the highest was a diatomaceous earth with 83.9. The predominant insects in decreasing order of abundance were the lesser grain borer, long-headed flour beetle, flat grain beetle, and red flour beetle. Weight records were kept on each bin so loss by insect attack and other factors could be determined. At load-out after 42 months, corn with the malathion treatment had lost 6.5% in weight, with the inert dusts 8.1 to 15.0%, and the untreated check 17.8%. No determination was made of the amount of extraneous material such as insect frass remaining in the grain but it was considerable where there was heavy infestation. The inert-dust treatments affected flow rate

and speed of grain movement less at load-out than at load-in. Rate of flow was only 19% less than the malathion treatment at load-out but the reduction was 43% at load-in.

Malathion and one of two diatomaceous earths tested were effective in preventing insect infestation for 3 years in dry wheat ranging 10 to 12% moisture and stored in 3,250-bu. circular metal bins in Kansas. Another diatomaceous earth and two silica aerogels were not effective. All check bins of untreated wheat became heavily infested.

Two diatomaceous earths and one silica aerogel kept shelled corn in the 12 to 13% moisture range insect-free for 3 years, stored in 3,250-bu. circular metal bins in Illinois. A second silica aerogel was only slightly less effective. Malathion kept the corn insect-free the first year, three bins of five were lightly infested after 2 years with an average of 0.24 insect per 1,000 grams, and all five bins were infested after 3 years with an average of 3.5 insects per 1,000 grams. (Unclassified)

In replicated 4-bu. bin tests, a silica aerogel at 60 pounds per 1,000 bu. of hard red winter wheat gave almost complete protection against the lesser grain borer for 12 months. A diatomaceous earth and the standard malathion treatment were slightly less effective. (MQ 1-27(Rev.))

Concentrations of more than 35% of carbon dioxide and less than 14% of oxygen were maintained for 4 days in the interstitial atmosphere of wheat in 500-bu. metal bins when purged with carbon dioxide. This combination was shown in laboratory tests to be effective in controlling many stored-grain insects. An inexpensive recirculation system was designed for the 500-bu. bins, along with a set of control devices for the automatic application of the carbon dioxide to maintain the desired concentrations of atmospheric gases. The control system uses a solenoid, a timer, and a flometer. This system might also have a potential use for aiding in the distribution of fumigants in grain bins. (MQ 1-60)

Attempts to achieve hermetic storage in underground and aboveground bins of shelled corn in Uruguay were not very successful in the earlier stages of a 5-year study. The project has ended, the bins have been unloaded, and some final data have been submitted. The results reported are quite variable. It appears that hermetic conditions were finally obtained in some bins where the oxygen content was low, the carbon dioxide was high, and at least some quality factors were maintained at a satisfactory level. (S9-AMS-6(a))

About 800 varieties of wheat from the World Collection were screened in India for resistance to attack by the rice weevil. Less than five weevils per test sample emerged from about 5% of the varieties. Of 300 varieties tested against the lesser grain borer, 5.6% showed resistance to attack. (A7-MQ-1(a))

2. Biology, Ecology, and Physiology. Laboratory tests showed that confused flour beetle adults preferred wheat containing 1 to 4% of cracked wheat or elevator dust over cleaned wheat. Also, 30 to 40% more progeny developed in wheat with 4% dockage than in cleaned wheat. (MQ 1-38)

Tests with olfactory apparatus and organic solvent extracts of adults show the presence of a male attractant in female Angoumois grain moths. The extract on filter paper caused a premating response by males as strong as that caused by females. Virgin females were more attractive than mated ones to males, and they were most attractive 48 to 68 hours after emergence.

There has been no satisfactory way to study nutrition of the Angoumois grain moth because newly hatched larvae bore into kernels of grain and complete their development to the adult stage, completely hidden. A significant new finding is that larvae will readily enter and grow in kernel-size pellets made with various proportions of the nutrients found in whole wheat kernels. Thus for the first time we have a way to study the development of larvae in food media of known, controlled composition. The developmental period to adult emergence is about 35 days in wheat kernels. Preliminary explorations show that development required 140 days in a pellet made almost entirely of endosperm. When only 1% of germ was added the period was reduced to about 100 days. Further study with varied diets will be conducted. In another phase of work a true-breeding population of red-eyed Angoumois grain moths has been developed from the descendants of a rare red-eyed male and a typical black-eyed female. There are indications the trait is recessive. Further knowledge of the inheritance of the character could provide a valuable tool for other research. (Cooperative Agreement, Kansas State University)

Studies in India showed that khapra beetle larvae survived at 68°F., but there was hardly any growth. At 86°F. some larvae enter a quiescent stage or diapause but this did not occur at 95° and 98.6°F. Diapausing larvae showed a considerable increase in fat and glycogen content over that in normal larvae. The materials are stored as energy sources for diapause. Studies of the changes in these metabolites during transformation from pupa to adult showed a reversal of what happens during the initiation of diapause. (A7-MQ-3(a))

A 5-year study in Israel was concluded on the influence of environmental conditions on population dynamics of the khapra beetle. A few of the many findings are summarized as follows: (1) Microflora studies showed that the percentage of wheat infested with Alternaria drops after the khapra beetle lives in the wheat. However, the percentage of germ infested with Aspergillus flavus rises from 17.6 to 51.5 in wheat and from 12.5 to 86.6 in barley. The dominant fungus found in larval feces was A. flavus with A. fumigatus second, (2) the fungi have little or no direct effect on the life cycle of the beetle, but the fungi the insects spread cause an increase in grain moisture and temperature, both of which are beneficial to growth and longevity of the beetle, (3) it was found that the presence of feces in

food extended the length of the larval periods and induced diapause. Several substances known to exist in the feces were fed separately and high concentrations of allantoin, urea, and uric acid caused larvae to diapause, (4) water and petrol-ether extracts of feces were tested. The petrol-ether removed the substance causing diapause but the water did not, (5) of nine antibiotics tested, tetracyclin and tyrothricin had the greatest effect in prolonging larval life and inducing diapause. They were more effective at low concentrations than at high ones, (6) the information was published that crawling larvae leave a factor in their wake that attracts other larvae of the same species. In subsequent research these results could not be duplicated, therefore, a notice was published correcting the earlier report, (7) a substance produced by virgin male or female adult khapra beetles was found to attract both virgin males and females of the same species. The pheromone, therefore, functions as a congregating substance rather than as a sex attractant. It was found to repel adult red flour beetles, Tribolium castaneum, (8) marked photonegative responses were found in khapra beetle larvae. The negative response to light with short wavelengths was distinctly stronger than two long wavelengths. Ten different pairs of illumination combinations were tested and larvae preferred long wavelengths over short ones, with the exception that they preferred violet over blue, (9) adult khapra beetles also displayed a strong photonegative response. A higher proportion of females than males were found on the dark side both in single-sex and mixed-sex groups, (10) larvae and adults were both distinctly hygronegative in all gradients tested. Reactions were more pronounced in tests with groups than with individuals. When the antennae of adult males and females were removed they lost their ability to respond to moisture gradients. The investigators considered this as proof the hygroreceptors are located on the antennae, a condition known to exist in some other stored-product insects, (11) sixteen manuscripts were prepared from results of this project and most have already been published. (A10-AMS-11(k))

3. Improved Pesticidal Control. Serious distributional deficiencies were found when wheat, corn, or grain sorghum at 60° F. or less were fumigated by gravity penetration in 9,000- or 12,000-bu. metal bins with an 80:20 mixture of carbon tetrachloride and carbon disulfide or a 75:25 mixture of ethylene dichloride and carbon tetrachloride. Test insects were used to determine the effectiveness of fumigation at the different grain temperatures. Air-gas samples were drawn from different locations within the grain mass at intervals through 3-day fumigation periods to determine by gas chromatography the concentration distribution of fumigant components throughout the grain at succeeding time intervals, as well as to determine the ratio of components existing at different times and locations. Rapid sorption of the carbon tetrachloride from the 80:20 mixture and the ethylene dichloride from the 75:25 mixture at low temperatures greatly reduced the effectiveness of the fumigations. It also created a definite fire hazard with the 80:20 mixture because of the increased carbon disulfide ratio as the gas moved down through the grain mass. The fire hazard would be even greater if the fumigant dosage were increased in an attempt to compensate for the decreased efficiency at lower temperatures. (MQ 1-16 (Rev.))

When the 80:20 or 75:25 fumigant mixtures were applied to cold grain of 60° or less by the closed-recirculation method, acceptably uniform distribution and excellent mortality of test insects were obtained with dosages as much as 1 gallon per 1,000 bu. lower than those used for gravity fumigation. Component ratios of the 80:20 mixture were similar to the original throughout the grain mass. When the 75:25 mixture was applied, higher concentrations of the carbon tetrachloride than of ethylene dichloride were recorded in over 84% of the samples analyzed. Therefore the ratio of the gases as they reached the test insects was quite different than the 75:25 component ratio of the mixture as applied. This research shows that when grain temperatures are below 60° the 80:20 fumigant should be applied by closed-recirculation rather than by gravity penetration, and that this method should be used for the 75:25 fumigant below 70°F. (MQ 1-16(Rev.))

The effectiveness and persistence of newly-applied malathion in wheat were not altered by aeration at a normal air-flow rate and under atmospheric conditions of 80°F. and 60% relative humidity. A loss in effectiveness when aerated at 75% relative humidity could not be attributed directly to a loss of toxicant from the treated wheat on the basis of available residue analyses. These results and data from previous tests where it was not possible to correlate residue analyses and bioassay results, raise some questions that need investigation. (Exploratory)

Further tests with phosphine fumigation of processed cereal products in rail cars show that 165 aluminum phosphide pellets per 1,000 cu. ft. gives highly effective results in standing or rolling cars when proper procedures are followed. Two new techniques for applying the pellets were tested and found effective. In one method the pellets are crushed and in the other they are ground and the dust is blown into the cars. Both methods produce gas almost instantly instead of after 3 hours as with whole pellets. Attaining a lethal concentration of gas so promptly improves the efficiency of the fumigation operation. (Exploratory)

Studies on the effect of sublethal dosages of synergized pyrethrum on the rice weevil revealed that certain conditions of exposure increased rather than depressed the production of progeny. This is the first recorded evidence of such an effect. (Exploratory)

Phosphine was found effective as a space fumigant in a test conducted in pilot flour mill. The grinder-blower method of dispensing aluminum phosphide pellets was used. Another test showed that aluminum phosphide pellets could not be used successfully for the spot fumigation of unsealed flour mill machinery and equipment. (Exploratory)

Tests were conducted to study three factors that were believed might influence the deposition and distribution of malathion on bulk shelled corn when applied by the forced-ventilation of aerosols. It was found that grain temperature was not as important a factor as aerosol particle

size and rate of airflow. Complete mortality of test insects was obtained at depths of 14 feet of grain when aerosol particles of 0.4 micron mass median diameter were moved through the grain with an airflow rate of 0.3 cubic foot per minute. (Exploratory)

Bay 77488 was more effective at 5 ppm on wheat than was malathion at 8 ppm against rice weevils, cigarette beetles, and confused flour beetles in small-jar tests after aging 6 months. These insects did not infest the wheat treated with Bay 77488 but some of each species survived and reproduced in the malathion-treated wheat. The Bay compound is of particular interest because of its extremely low toxicity to warm-blooded animals. (MQ 1-15)

4. Toxicology of Pesticides. A five-year study in Israel on the effect of ethylene dibromide (EDB) on farm animals has been completed after the development of much valuable information. Some of the results have already been published in ten papers in scientific journals and at least four others will follow. EDB is a component of several fumigant mixtures commonly used in this country to control insects in grains, foods, and animal feeds. About 10 years ago it was found that EDB in poultry feed would reduce the size and number of eggs laid, and a little later that high amounts would stop egg production irreversibly. This raised serious questions about the possible effect of EDB on the reproductive system of farm animals. The research in this project has provided at least partial answers to many important questions. Areas of hazard are delimited and conditions for the safe use of EDB have been defined. Some specific findings are summarized as follows: (1) residue analyses were made in several grains, oil seeds, dried and fresh fruits, vegetables, and feed and the amount of EDB present was recorded immediately after fumigation and at periods up to 70 days. Residue analyses at different times after fumigation were also made on carbon tetrachloride, carbon disulfide, chloroform, and trichloroethylene, all compounds that are used in fumigant mixtures with EDB. (2) It may be necessary to aerate feed for laying hens 30 days or more after EDB fumigation to bring the residue down to a level that will not affect egg production. Careful attention must be given to proper aeration. (3) Pertinent to a new German food law banning any carbon tetrachloride residues in grain, under some test conditions fumigated grains contained about 3 ppm after 1 week of aeration, 2 ppm after 2 weeks, 1 ppm after 6 weeks, and 0.5 ppm after 10 weeks. (4) A simple test was developed that permits non-technical personnel to detect EDB in fumigated commodities down to a level of 15 ppm. (5) Laying hens were the most susceptible to toxic action of EDB of the various laboratory and farm animals studied. Ten ppm of EDB in the mash is the upper limit to avoid adverse effects. This corresponds to about 1 mg/kg daily intake. Even this amount in prolonged feeding may cause reduction of egg size. (6) Bulls fed 2 mg/kg of body weight of EDB daily developed abnormal spermatozoa after 2 weeks. This amount of EDB would be equivalent to about 100 ppm in the grain or feed concentrate of an animal weighing 1,100 pounds and fed 22 pounds of concentrate per day. This concentration would be present only in mash containing unaerated grain and aeration for 3 to 7 days after fumigation would reduce the residue to a safe level of 50 ppm or less. (7) Rats and cockerels were not sensitive to as much as 200 ppm of EDB in the total diet as far as growth, feed consumption, sexual development, and general

health were concerned. (8) Calves a few days old were seriously affected by 10 mg/kg of EDB daily and died after a few weeks. A dose of 40 mg/kg daily was lethal after 2 days. (9) Doses of 2-3 mg/kg of EDB daily caused no observable detrimental effects on milk cows, calves, or yearling sheep. (10) Extensive biochemical and toxicological studies developed a great deal of information on the mechanism of acute poisoning by EDB and on its metabolites. A theoretical detoxification mechanism has been proposed. A significant contribution has been made to the knowledge of the toxicology of EDB. (A10-AMS-4(a))

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AREA 4a

RICE - MARKET QUALITY

Problem. Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation. There is need for developing more effective ways of preventing insect infestation during storage, handling, processing, packaging, and transportation of rice. Attention must be given to finding control methods that will minimize or eliminate pesticide residue hazards. To maintain the quality of rice, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products and more equitable prices to all concerned, new and improved procedures for measuring quality factors must be developed for use in inspection, grading, and standardization operations.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station.

The Federal scientific effort in this area totals 2.0 scientist man-years: quality evaluation 1.0 and quality maintenance 1.0.

A grant to the Department of Plant Chemistry, Valencia, Spain, provides for a study on storage changes in milled rice and their relation to market quality. Its duration is for 4 years, (1964-68) and involves P.L. 480 funds with a \$62,479 equivalent in Spanish pesetas.

A grant to the National Institute of Hygienic Sciences, Tokyo, Japan, provides for a study covering the cause and development of mycotoxins in rice as a result of invasion and growth of fungi during postharvest conditioning, handling and storage. Its duration is 3 years (1965-68) and involves \$33,164

A grant to the Central Food Technological Research Institute, Mysore, India, provides for a study covering the control of microflora and related production of mycotoxins in stored sorghum, rice and groundnuts. Its duration is 5 years (1966-71) and involves P.L. 480 funds with a \$106,533 equivalent in Indian rupees.

There is also a Departmental program of entomological research on the prevention and control of insect infestation in rice in the marketing channels. It was formerly headquartered at Fresno, California, but was inactive this year. Just before the end of the reporting period the project was transferred to Beaumont, Texas, and a new research entomologist was employed for assignment to the investigations. A cooperative agreement was signed with the Agricultural Experiment Station of Texas A&M University for the operation of this project. Approval was obtained for the erection of a \$45,000 building to house the research, and construction has begun on the property of the Rice-Pasture Research and Extension Center at Beaumont. Much of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," is applicable to the problems in rice.

A grant to the Tokyo University of Agriculture, Tokyo, Japan, is for a 3-year study, part of which is on the constituents of rice that attract insects. It continues until August 1968 and involves P.L. 480 funds with a \$38,622 equivalent in Japanese yen.

Line Project MQ 1-9, a study of gas fired infrared rice dryers for insect control, was terminated in September 1966.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 2.7 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Degree of Milling and Color of Rice. The Rice Ratiospect, an instrument for measuring degree of milling, color and degree of parboiling, was field tested in the Rice Inspection Office, Consumer and Marketing Service, Houston, Texas. Meter readings corresponding to various official grades now in use were established by measuring type samples. A high correlation of meter readings versus visual grades was obtained except for samples containing large amounts of broken kernels. A similar field test was begun at a commercial mill to determine the feasibility of using the instrument for control of degree of milling. (MQ 3-82)

B. Quality maintenance in conditioning, handling and storage

1. Microbiological, Chemical and Physical Deterioration of Rough Rice. Rough rice stored under optimum or near optimum conditions for the development of storage fungi showed a cyclic increase and decrease in the rate

of respiration. The cyclic phenomenon has been measured with rice sterilized and not sterilized before inoculation with spores of the Aspergillus flavus group. Visual observations indicate that heavy spore formation accompanies the increased rate of CO₂ evolution. (MQ 2-7(Rev.))

2. Storage Changes in Milled Rice. Large differences between different layers of the rice kernel were found in individual sugars, soluble protein fractions and amino acid composition, enzyme activities (alpha-amylase, beta-amylase, proteases, lipoxidase, and lipase) and stability of lipids. Storage for 10 months caused no change in total lipid content but free fatty acids increased whereas neutral fats and phospholipids decreased. Quantitatively, these changes were greater in the outer layer of the kernel.

The procedure previously developed to determine the content of sulfhydryl and disulfide groups (SS and SH indices) has been applied to 13 varieties of rice and a highly significant correlation has been found between the SS index and quality (as determined organoleptically). (E25-AMS-9)

3. Mycotoxins in Rice. A cooperative study with the Transportation and Facilities Research Division at Beaumont, Texas, of the effect of environmental factors on the development of aflatoxins in stored undried rice on a pilot-sized scale was continued with the 1966 crop. Moisture contents in excess of 20% (wet basis) were shown to increase greatly the probability of aflatoxin contamination when other primary controlling factors, such as ambient temperature and extent of aeration, are favorable for the production and accumulation of the toxins.

The distribution of aflatoxin in the rice kernel was shown to vary with the stage of development of Aspergillus flavus infection. Thus, the milling process can be expected to remove toxin in contaminated brown rice.

(MQ 2-103)

Five hundred and seventy-five of the Penicilli and Aspergilli isolated from 219 samples of milled rice in Japan were identified to species level. The predominant Penicilli were the Penicillium canescens, P. cyclopium and P. citrinum series. The Aspergillus glaucus and A. restrictus groups of the Aspergilli were most prevalent.

Out of a total of 113 strains of fungi, 51 of which were isolated from rice, only 2 strains of the A. flavus group could be demonstrated to produce aflatoxins. The two strains were isolated from flour and constitute the first report of aflatoxin-producing fungi isolated from foodstuffs in Japan. (All-MQ-2)

C. Prevention of insect infestation

1. Biological and Physical Control. Isolation of the insect-attractant material from polished rice by steam distillation was not successful. Isolation by nitrogen aeration gave a very small yield. Solvent extraction was successful with methanol, ether, acetone, normal hexane, and water. Ether appeared to be most suitable. The attractant has been extracted from the concentrated ether extract into a water solution at 70° C. in a rotating agitator. This water extract displayed a strong luring activity for rice weevils and had a pH value of 3.9. The water extract was evaporated in vacuum and the distillate fraction was highly attractive. The residual liquid was treated with a saturated sodium bicarbonate solution, then treated with sulfuric acid and ether to separate out another attractant fraction, acid in nature. Yield of the two crude attractants is estimated at less than 30 mg. per kilo of polished rice. Study of the two fractions is now being made with thin-layer chromatography and gas chromatography. Isolation of two attractant fractions from rice bran has also been made. (All-MQ-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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Quality Maintenance in Conditioning, Handling and Storage

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Boller, R. A. and H. W. Schroeder. 1966. Aflatoxin producing potential of Aspergillus flavus-oryzae isolates from rice. Cereal Science Today 11:342-344. (MQ 2-103)

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Prevention of Insect Infestation

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Henderson, Lyman S., and Walter W. Dykstra. 1966. Control of insects and rodents in stored rice. Preprint for U. S. Delegation to the 11th Session of the Working Party on Rice Production and Protection, International Rice Commission, FAO, July 23-28, 1966, Lake Charles, La.

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AREA 4b

FEED AND SEED - MARKET QUALITY

Problem. Many methods of determining seed and feed quality currently in use require too many man-hours, impose tedious work on the analyst, are incapable of high degrees of standardization, and do not provide accurate indices for quality. Practical methods are needed for determination of such quality factors as mechanical purity, genetic purity, germination, vigor, weed seed content, protein content (of feeds) and infection with disease organisms. The deleterious effects of high temperatures and relative humidities on stored seed are well known but little is known about the part played by storage molds, especially the minimum temperature-relative humidity combinations under which the storage molds survive in stored seed. There is urgent need to increase basic research which would serve as a basis for developing more practical methods of determining seed and feed quality and for recommending improved practices of storing seed.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-time program on seed and feed research involving botanists, plant physiologists, plant pathologists, engineers, and chemists engaged in both basic and applied research on quality evaluation and quality maintenance of seed. This research is conducted at Beltsville, Maryland, and College Station, Texas, and by research contract with the Oregon Agricultural Experiment Station and Analtech, Inc., Wilmington, Delaware, and by cooperative agreement with Mississippi State University.

The Federal effort in this area totals 7.75 scientific man-years: quality evaluation, 6.25, and quality maintenance, 1.5.

A P.L. 480 grant with the Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. The project ran from 1961 to 1966 and involved \$31,016 equivalent in Brazilian cruzieros. This project was terminated during the 1967 fiscal year.

A P.L. 480 grant with Rijksproef-station, Wageningen, Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. The duration of the project is five years, beginning 1963, and the total grant in Dutch guilders is the equivalent of \$55, 918.

A P.L. 480 grant with Samenprufstelle, Munster, Germany, provides for a study of the biological and environmental factors affecting the physiological maturity of grass seeds. The duration of the original project was for three

years, beginning April 1965, and the total grant in German marks was the equivalent of \$31,775. An extension of two additional years and an increase in the grant of \$22,675 equivalent has been approved.

A P.L. 480 grant with Forschungsgemeinschaft für Saatgutforschung, Reutlingen, Germany, provides for a study of methods for maintaining the germination of seeds in storage and in trade channels. The project has a duration of five years, beginning April 1965, and the grant in German marks is the equivalent of \$52,338.

A P.L. 480 grant with the Agricultural Research Station, Beit Dagen, Israel, provides for research to find a satisfactory invisible marker of seeds in commercial channels and for research purposes. The project runs for three years, beginning February 1965, and the total grant in Israeli pounds is the equivalent of \$45,640.

A P.L. 480 grant with the Indian Agricultural Research Institute, New Delhi, India, provides for a study to evaluate the X-ray technique for detecting empty seeds in purity testing and for determining seed viability. Its duration is five years, beginning October 1965, and the total grant in Indian rupees is the equivalent of \$37,464.

A P.L. 480 grant with the Weizmann Institute of Science, Rehovoth, Israel, and the Hebrew University, Jerusalem, Israel, provides for research to isolate and determine the structure of germination inhibitors in seeds. The project runs for three years, beginning October 1964, and the total grant in Israeli pounds is the equivalent of \$50,722.

A P.L. 480 grant with the Israel Institute of Technology, Haifa, Israel, provided for a study to develop tests for nutritive value of cereal grains and feeds. The duration of the original grant was 4 years (1961-65) and an extension of 1 additional year was approved, making the completion date June 1966, but no final report has been received. The total grant involved an expenditure of \$53,298 equivalent in Israeli pounds.

The following project was terminated during this period: "Microbiological determination of grass seeds during marketing" (MQ 2-62).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 3.6 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Development and Standardization of Seed Testing Equipment. A new seed blower using the Venturi principle was designed and constructed. A semi-automatic sample divider designed to extract from the sample received an exact quantity of seed for a working sample was designed and constructed. A torsion balance and a photoelectric switching circuit are incorporated into the model machine. (MQ 3-21(C) (Rev.))
2. Seed Metabolism. The process of polysome formation, which had been previously shown to occur within 15 minutes after exposure of embryos to water, was studied with tobacco mosaic virus RNA. It was established that the process requires ATP, ribosomes and at least two supernatant components. (MQ 3-32)
3. Determining the Purity of Certain Grass Seeds. Additional tests conducted to determine the toxicity of certain low surface tension solvents suitable for use with the flotation method of purity analyses of grass seed led to the discovery of interactions which occur when two or more solvents are mixed, some of which are beneficial. Reports from other researchers show the accuracy of the flotation method compares favorably with the official method for little bluestem (Andropogon scoparius) and big bluestem (A. gerardi). Purity analysis can be made by the flotation method in only one half of the time required by the official method. (MQ 3-39)
4. Development of Seed Germinator. An automatic condensate evaporator was designed and constructed to overcome the problem of drying out of substrate materials. (MQ 3-48)
5. Processing Grass Seed for Laboratory Testing. Tests of a modified blender to separate multiple florets into single florets showed this device to be inadequate because of insufficient separation or excessive damage to the seeds. Various laboratory machines which can be used or modified to efficiently remove awns or other undesirable appendages will be investigated. (MQ 3-54)
6. Seed Vigor. Specific recommendations for a respiration test for corn seed vigor were published in the AOSA Proceedings. The respiration test was also found to be useful for detecting loss of pea seed vigor due to mechanical damage during combine harvest and for determining seed quality of acid-delinted cotton and snap bean seeds. Respiratory measurements only 60 minutes after wetting barley can distinguish between vigorous and non-vigorous lots. Seeds of corn, wheat, sorghum and radish given growth-inhibiting doses of gamma irradiation were distinguished from non-irradiated controls by measuring respiratory rates and determining the respiratory quotients in an atmosphere of 100% oxygen during the first 6 hours of germination. Studies on lettuce seeds before and after exposures to red (germination stimulating) and far-red (germination inhibiting) light indicated that changes in respiration occur 2 to 3 hours after the application of the light treatments. (MQ 3-55)

7. Protein Content of Feed Grains. A technique was developed for predicting protein content in varieties of grain sorghums by measuring the change in reflectance readings taken before and after water addition. The change in reflectance readings for a given variety was directly related to its protein content. (MQ 3-58).

8. Verification of Varietal Designations of Crop Seeds. A seed protein variant was discovered in soybean varieties. All varieties tested had either type A or type B protein but none had both. The inheritance of the variant was established by using three parental crosses and their respective F_1 , F_2 and F_3 selfed progeny. The evidence clearly indicates a simple Mendelian ratio involving two codominant genes operating at a single locus. Only a few genetic systems involving plant proteins have been described to date. Specific morphological growth patterns have been determined for certain varieties of soybeans which should aid in distinguishing and identifying these varieties (MQ 3-64)

9. Detection and Identification of Seedborne Pathogenic Fungi. The reflectance of visible light from conidia of one isolate each of twenty species of Aspergillus was measured over a range of 440 to 700 nm. Reflectance curves produced by the conidia of a number of species were sufficiently far apart to serve as a means of identifying the taxa. Large numbers of isolates of each species will have to be studied before a practical method can be developed. (MQ 3-67)

10. Temperature and Light Effects on Seed Germination. Upon completion of the thermogradient plate, an experiment was conducted with four inbred lines of corn and various crosses. The hybrid seed germinated over a broader span of temperature than did seed of the inbred parents in the same period of time. Possibly this type of expression might be used to quantitate hybrid vigor.

Two types of light responses in seeds of many ecotypes of Eragrostis curvula were verified: (1) high germination in response to light after a favorable dark-imbibition period and (2) lowered germination when light was applied during the early hours of darkness. (MQ 3-83)

11. Predicting the Longevity of Seeds in Storage. An accelerated aging test was developed in which seeds are placed at a high temperature and humidity for a brief period and then tested for germination. Preliminary results with a number of field and vegetable crop seeds indicate that the accelerated aging test has good potential of predicting the storability of seed lots. (MQ 3-94(CA))

12. X-rays and Radiograms of Aids in Analyzing Seeds. Radiograms of wheat, barley, corn cucurbits, rice and other crops revealed the extent of embryo and endosperm development as well as the presence of broken, shriveled, damaged and empty seeds. The presence of insects inside seeds can be detected by X-rays and in some instances identification can be made. (A7-MQ-2(a))

13. Germination Inhibitors in Seeds. Methods have been developed for the extraction, isolation and characterization of phenolic germination inhibitors from barley. Catechuic aldehyde was identified for the first time in barley and found to be a potential inhibitor of lettuce seed germination. Two other new germination inhibitors, syringaldehyde and protocatechualdehyde, were isolated from the seed coats of barley. (A10-MQ-1)

14. Invisible Marking of Seeds. Ferric and ferrous compounds were found to be most promising as seed markers, especially ferric citrate, but different stains had to be used for the various types of seeds. (A10-MQ-5(a))

15. Biological Basis of Physiological Phenomena in Seed Germination. The first 6-month report indicates two contrasting patterns of increase in enzymatic activity in germinating pea seeds. (A10-MQ-6)

16. Factors Affecting the Physiology of Grass Seeds. Seeds of Kentucky bluegrass and orchardgrass harvested in the early dough stage, showed lower germination than those harvested in the late dough or ripe stages. In orchardgrass and annual ryegrass, dormancy was more of a problem in the seeds harvested in the immature stage. Alternating temperatures and gibberellic acid were more effective in improving the germination of Kentucky bluegrass than that of timothy, meadow fescue, orchardgrass or annual ryegrass. (E10-MQ 3(a))

17. Routine Testing Methods for Seedborne Organisms. A modified blotter test for seed "health" testing was developed. The key principle lies in damaging or killing seeds or seedlings to be tested for seed-borne fungi, resulting in stimulating growth of certain seed-borne fungi. Initially, killing was done to control germination of the seeds and seedlings by application of 2,4-D. Upon finding that the 2,4-D stimulated growth of fungi, the principle was extended to killing the seedlings by freezing at -20°C . Specific test procedures for a number of fungi on seeds of different crops were worked out. (E19-AMS-11(a))

18. Moisture Levels for Seed Germination. Maximum germination was found to occur over a range of moisture levels of the substratum rather than at a specific level. (S3-AMS-2(a))

B. Quality maintenance in storage

1. Deterioration of Grass Seeds in Storage. Efforts were made to produce seeds of annual ryegrass under sterile conditions for use as germ-free controls.

Little progress has been made in sectioning seeds to get thin slices for microscopic study. Because of the hard, brittle nature of the seed, the sections break easily. (MQ 2-138)

2. Preserving the Germination of Seeds. Desiccation of seeds over quicklime follows a similar pattern regardless of species. The first third of moisture was lost within 2 days, the second third within 2 weeks and loss of the remainder required several months. Moisture (vapor) loss and uptake were different in legume seeds with hard seed coats. The rate of loss was fast at first and then gradual over a long period of time. Even though water vapor penetrates the seed coat, the rate of uptake is so slow that germination cannot proceed in a normal manner. The best vapor barrier for seed packaging materials was found to be a bag with aluminum foil between the double walls of paper (this was previously found by American researchers). (E10-MQ-1(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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- Marcus, A. and J. Feeley. 1966. Ribosome activation and polysome formation in vitro; requirements for ATP. Proc. Natl. Acad. Sci. 56:1770-1777. (MQ 3-32)

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- Woodstock, L. W. and O. L. Justice. 1967. Radiation-induced changes in respiration of corn, wheat, sorghum, and radish seeds during initial stages of germination in relation to subsequent seedling growth. Radiation Bot. 7: 129-136. (MQ 3-48)

Quality Maintenance in Storage

- Kulik, M. M. and O. L. Justice. 1966. Survival of two storage fungi after gamma radiation of host seeds. Radiation Botany 6:407-412. (MQ 2-138)
- Lowig, E. 1966. Moderne Saatgutveredlung. Saatgut-Wirtschaft f. Samen und Saaten. Nr. 8:270-272. (E10-MQ-1(a))
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- Lowig, E. 1966. Ermittlungen über die unterschiedliche Wasseraufnahme durch die einzelnen Samenbestandteile im Verlaufe von Quellung und Keimung. Samenfachhandel u. Pflanzenzüchter (Bad Godesberg). 10-11. (E10-MQ-1(a))

AREA 5

LIVESTOCK AND MEAT - MARKET QUALITY

Problem. To insure that grades are a true measure of palatability, a better understanding of the relationship between the physical and chemical properties of muscle and quality must be established. This information can then be used to devise objective methods for measuring the degree of tenderness, juiciness, and flavor in meat cuts.

The dominant method of merchandising meat in retail stores today is through the use of self-service display cases. Therefore, quality and appearance of the meat is of primary importance and research on maintaining meat quality and shelf-life is a necessity for the success of this type of merchandising. Lighting conditions required to evaluate meat quality need to be defined so that the meat quality attributes can be properly assessed.

The maintenance of desirable meat quality during various transport techniques and the determination and evaluation of the various methods of shipping fresh meats to European markets are primary research needs if we are to expand our market for fresh meats.

Wholesomeness of a meat carcass and maintenance of meat quality presupposes proper handling, slaughter and processing of disease-free animals that are not contaminated with toxic chemical residues. Development of rapid objective methods to detect unwholesome characteristics and deterioration of meat quality would aid the regulatory agency in their consumer protection efforts and would be useful to the meat industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists and food technologists in basic and applied research to maintain and improve the market quality of meat and to develop objective methods for quality evaluation. Studies are being carried out at Beltsville, Maryland, partly in cooperation with the Animal Husbandry Research Division and the Transportation & Facilities Research Division, ARS, the Livestock Division, Consumer & Marketing Service, the Radiological Laboratory of the Johns Hopkins Medical Institute, and under cooperative agreement or contract with the Universities of Florida, Illinois, Missouri, Oklahoma, Wisconsin and with Texas A&M.

The Federal scientific effort devoted to research in this area, exclusive of contract research totals 6.2 scientist man-years divided as follows: quality evaluation, 5.2, and quality maintenance, 1.0.

The following project was terminated during this period: "Objective methods for evaluating the market quality of livestock and meat." (MQ 3-34)

A PL 480 grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide and nitrogen on chemical and physical properties of refrigerated meats. The project ran from 1963-67 and was extended to 1968 and involves \$57,524 equivalent in Finnmarks.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 19.1 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective Measurement and Evaluation of Quality

1. Objective Methods for Evaluating the Market Quality of Livestock and Meat.

Research conducted under a cooperative agreement with Texas A&M showed that freezing lamb leg roasts and loin chops resulted in a significant increase in shear force value and decrease in flavor score and taste panel acceptance.

Four hundred and sixty frozen stored meat cuts from Choice and Good carcass grade beef (A+ to B- and young A- maturities) and calf of Good carcass grade were evaluated at the University of Missouri and at Beltsville, Maryland. Relationships of palatability to carcass grade and maturity shown by whole meat cuts were generally opposite to those noted for ground meat samples. For whole meat cuts, there were minimal differences in odor and flavor of samples within Good carcass grade but Choice samples were generally more desirable. Differences in juiciness were observed only for inside round roasts with the highest juiciness associated with beef carcasses of A-maturity followed by calf. The highest tenderness scores of spencer roll steaks were associated with beef carcasses of A+ to B- maturities. (MQ 3-34)

2. Lighting Requirements for Evaluation of Meat Quality. Statistical analyses of data obtained from light studies showed: (1) color of meat samples illuminated with incandescent light was significantly more desirable (cherry-red) than the same samples evaluated under deluxe warm white or cool white fluorescent light; (2) samples evaluated at 50 foot-candles had a more desirable color rating than the same samples judged at 15 foot-candles; (3) a significant difference (5% level) existed between the incandescent and deluxe warm white fluorescent lights when evaluating degree of marbling; and (4) no significant difference was found between 15 and 50 foot-candles of illumination when judging degree of marbling. (MQ 3-59)

3. Relationship of Marbling to the Palatability of Beef. A study to determine the influence of marbling upon the tenderness and juiciness of beef differing in maturity was carried out under contract with the University of Wisconsin. Sixty carcasses were evaluated for shear and taste panel scores,

color by transmittance, pH by probe and homogenate, expressible juice, ether extractable material, extractable protein, sarcoplasmic protein, myofibrillar protein, sarcomere length, fiber diameter, muscle bundle size and fat distribution. Statistical analyses of the data are underway. (MQ 3-60(C))

4. Objective Measurements of Beef Maturity. Preliminary investigation of five muscles from 18 carcasses of beef ranging in age from 12-24 months, indicates a significant increase in concentrations of free amino acids occurs during post-mortem aging of the carcasses. Apparently, a high positive linear correlation exists between chronological age of the beef and phospholipid content of the muscles. Changes of triglycerides, free fatty acids, unsaponifiables, sarcomere length and tenderness are also being examined for relation to maturity and aging. (MQ 3-62)

5. Methods for Cutting and Thawing Frozen Meat. A survey of methods for excising meat inspection samples from blocks of imported frozen boneless meat was completed under contract. Band saws of at least 2 h. p. were better than the guillotine-type slicer or the circular saws tested. Hot water defrosting of the frozen meat samples proved more effective than hot air. Two-inch excised meat slices, placed in plastic bags and immersed in 125°F. water thawed in 25 minutes. Studies of dielectric and microwave energy thawing have been initiated under contract. (MQ 3-91(C)(Rev.))

B. Quality Maintenance in Handling, Packaging and Storage

1. Refrigerated Meats Stored in Atmospheres of Carbon Dioxide and Nitrogen.

Storage atmospheres containing 40% CO₂, 90% N₂ and 95% N₂ were investigated for their influence on (1) keeping quality of meat; (2) chemical changes; and (3) changes in microbial flora and numbers. The keeping time of meat stored in N₂ was 12 days whereas meat stored in 40% CO₂ was organoleptically acceptable for about 26 days.

Keeping time was greatly influenced by number of bacteria on the meat surface immediately after flaying. Numbers of bacteria on the surface and in the interior of meat stored in 40% CO₂ were considerably smaller than for the control (which was held in air at 0°C. and 95% relative humidity). Nitrogen storage of meat had little effect on bacterial counts. (E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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Quality Maintenance in Handling, Packaging and Storage

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AREA 6

OILSEEDS AND PEANUTS - MARKET QUALITY

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete revaluation of handling and storage methods for farmers stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artificial drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., and Beltsville, Maryland, and in cooperation with the University of Missouri, Columbia, Missouri, and the University of Arkansas, Fayetteville, Arkansas; research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State University.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves \$81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Asperigillus flavus Link and its infectivity to plants and harmfulness to animals. The project runs from 1963 to 1968 and involves \$129,250 equivalent in Israeli pounds.

A P.L. 480 grant with the Istituto di Industria Agrarie, University of Florence, Florence, Italy, provides for a study of the effect of long-term bulk storage upon quality of edible vegetable oils. The project ran from 1962 to 1966 and was extended to 1967 and involves \$26,345 equivalent in Italian liras.

The following project terminated during this period: Effects of the natural antioxidants of vegetable oils on change of oil quality during long-term storage. (MQ 3-25)

The Federal effort devoted to research in this program totals 6.0 scientific man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, where basic and applied entomological research is conducted on the problems of insect infestation, damage, contamination, and pesticide residues in peanuts in the marketing channels. There is cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, growers' cooperative associations, and various industry groups.

The Federal effort devoted to research on prevention of insect infestation was 1.7 scientist man-years. Much of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 6.0 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Natural Antioxidants in Vegetable Oils. Secondary oxidation products of heat treated (deodorized) samples of crude oils, refined oils, and oil mixtures were determined by analysis of carbonyl and aldehyde values (this involves 400 samples of refined and crude cottonseed, soybean, corn and safflower oils). A reasonable relationship between the two methods was found. Upon completion of tocopherol determinations, the project will be discontinued. (MQ 3-25)

2. Equipment for Grading Farmers Stock and Shelled Peanuts.

(a) Since fat acidity is a good indicator of the degree of deterioration of peanuts in storage, three methods for this determination were investigated: the AOCS method, a colorimetric method and a conductometric method. The colorimetric and conductometric methods checked closely with the official method. The conductometric method was the fastest and simplest to use. Accuracy of both methods was about the same.

(b) Cooperative tests of harvesting and field drying treatments of Spanish, Runner, and Virginia type peanuts with Agricultural Engineering Research Division personnel in Tifton, Georgia showed that mean flavor-rating differences among treatments were small and not statistically significant. Statistically significant results obtained from the belt drying tests of peanuts conformed to no apparent pattern. In the infrared drying tests, highly significant (at the 1% level) flavor degradation was demonstrated for the most severe treatment (4 minute exposures) for Spanish, Runner, and Virginia peanuts, even though initial moisture levels for Spanish and Runner nuts were below 25 percent.

(c) An experimental chopper was developed to comminute large samples of shelled peanuts, blend and screen the material through a 1/8-inch perforated screen and provide a representative subsample 1/20th of the original sample weight. It will perform the above operations on a 10-pound sample in approximately 5 minutes, including cleanup time, compared to over 20 minutes required for presently used equipment.

The experimental chopper gave representative subsamples for aflatoxin analysis from samples consisting of 600 kernels with only one kernel containing aflatoxin as well as representative subsamples from 10-pound samples of shelled peanuts containing low percentages of contaminated kernels. Subsamples for aflatoxin analysis were found to contain within 30 percent of the correct amount of contaminated material 97 percent of the time when the experimental chopper is used compared to only 45 percent of the time when present chopping equipment with dull blades is used. The blades on present equipment become dull after grinding only five 10-pound samples while the blades on the experimental chopper perform satisfactorily after grinding more than a hundred samples. (MQ 3-29(Rev.))

3. Rapid Detection of Molds and/or Fungal Metabolites in Peanuts.

(a) The rapid multi-column chromatographic method for detection of aflatoxin in peanuts was further improved. Some degree of quantification is possible by making up standard tubes for comparing with samples. Sensitivity is about 15-20 ppb.

(b) Peanut kernels with fungal growth tentatively identified to be Aspergillus flavus by visual examination were surface sterilized and cultured for positive identification of the fungus. The fungus was correctly identified by visual examination on 87 percent of 152 kernels. Although not 100 percent accurate, examination for visible growth of A. flavus on damaged kernels and other kernels was shown to be a simple, effective method to detect loads with high levels of aflatoxin contamination.

A study of the relationship between fat acidity and damage in farmers stock peanuts gave the following results: (1) fat acidity and total damage are highly correlated; (2) removal of damaged peanuts from the samples resulted in a significant decrease in fat acidity; (3) peanut type has an effect on fat acidity; and (4) fat acidity is a good index of mold damage, but it is not significantly better than presently used visual inspection methods.

(MQ 3-66(Rev.))

4. Objective Measurements of Market Quality in Raw Peanuts. Six carotenoids have been isolated from peanut oil and four (alpha carotene, zeta carotene, zeaxanthin and flavoxanthin) identified in addition to beta carotene and lutein previously reported. Carotenoid concentration rapidly decreases from the fourth to ninth week following pegging and little change occurs from the tenth to twelfth week. Actual carotenoid content increases from the fourth to seventh week and then remains stable through the twelfth week. Oil content increased from 22 percent at the fourth week to 56 percent at the twelfth week.

The volatile components of normal flavored raw peanuts have been investigated using combined gas chromatography and mass spectrometry. Components isolated by use of high vacuum distillation and identified were pentane, hexane, 1-hexene, acetaldehyde, acetone, methanol, benzene, ethanol, pentanal and hexanal. Hexanal is probably the major base component of raw peanut flavor.

Tests last year indicated that precooling peanuts before heated-air drying may reduce the amount of skin slippage.

A new method developed for estimating maturity in peanuts is based on the measurement of the skin thickness. Immature peanuts have a skin thickness over twice that of fully matured nuts.

(MQ 3-88)

5. Physiological and Biochemical Factors Involved in the Production of Aflatoxin by Aspergillus flavus. Selected enzymes, studied to determine the relationship between age of culture and their activity, were shown to decrease in activity with age and to have little activity eight days after growth initiation. Total lipid, phospholipid, protein and kojic acid content of the mycelium were found to increase with culture age. (A7-MQ-7)

B. Quality maintenance in handling, drying and storage

1. Methods of Long-Term Storage of Vegetable Oils and Relation to Oil Quality. Two reports covering research on this project are now being published as a Marketing Research Report and a paper in the Journal of the American Oil Chemists Society. (MQ 2-44)

2. Development and Control of Mycotoxins in Peanuts. A survey of the 1966 crop of Spanish peanuts in the Southwest was conducted in cooperation with TAES, OAES, the Southwestern Peanut Growers and Shellers Associations, Federal-State Peanut Inspection offices of Texas and Oklahoma, C&MS, and CR, ARS. The incidence of aflatoxin contamination of Southwestern Spanish peanuts in 1966 was quite low.

Dry, shelled peanuts were stored in a relative humidity of 85 percent at 25°, 30°, and 35° C. Aflatoxins in greater than trace amounts were not found for periods up to 5 weeks. The prevalence of species of Aspergillus flavus group infecting the kernels also did not increase significantly in this environment unless A. flavus inoculum (spores) was added in large amounts at the start of storage. (MQ 2-103)

A three-year survey of aflatoxin contamination in farmers stock peanuts marketed in North Carolina has been completed. No correlation was found between aflatoxin contamination and local weather conditions, time of marketing or location within the State.

Further studies have been made of the effects of atmospheric composition on the growth of A. flavus on high moisture shelled peanuts which were sterilized with propylene oxide, inoculated with spores from a toxin-producing strain of A. flavus, and stored in controlled atmospheres. The atmospheres used in the studies were 65, 75 and 85 percent carbon dioxide.

The results of a study to determine the effect of various windrow conditions on mold growth and production of aflatoxin showed that a rain during windrowing, particularly after the peanuts have dried below 15 percent moisture content, is probably the primary cause of molding and aflatoxin production after digging. The duration of the rain, air temperature, and humidity also play a role in aflatoxin production. If the rain occurs immediately after digging, the chances of aflatoxin contamination are low, but if it rains several days after digging or after the peanuts have undergone some drying, very likely aflatoxin production will take place. (MQ 2-107)

3. Effects of Storage Temperatures on Quality of Vegetable Salad Oils. Cottonseed and soybean salad oils (with no added synthetic antioxidants) were stored in 1-gallon sealed metal containers under 5 levels of heat

treatment for periods of up to 24 months. Flavor panel evaluations and chemical tests were made at 6-month intervals. Preliminary conclusions indicate that both cottonseed and soybean oils did not significantly change in quality at normal temperatures of dry storage (as compared with samples held frozen). As expected, differences have been found in the keeping qualities of the two oils at higher temperatures. (MQ 2-106(C))

4. Vegetable Oil Storage. For crude oils stored at 50° C, oxidability decreased in the order olive, soybean, and peanut. For refined oils, it was peanut, soybean, and olive. After 900 days of storage at 30° C, crude olive and soybean oils had exceeded the 100 peroxide value. However, crude peanut oil after 1089 days had only a peroxide value of 39. (E15-AMS-12)

C. Prevention of insect infestation

1. Biological and Physical Control. Laboratory tests with nitrogen purging of a simulated storage facility showed that oxygen must be reduced to 2% or less to kill insects in a reasonable time. With carbon dioxide purging, highly effective results were obtained with most insects when oxygen was decreased to 13% or less and carbon dioxide increased to 43% or more. For effective results against larvae of the dermestid beetle, Trogoderma glabrum, it was necessary to reduce the oxygen to 7% or less and raise the carbon dioxide to 60% or more with exposures of less than 14 days. (MQ 1-60)

Tests on the use of carbon dioxide in a commercial structure were conducted in a large concrete silo 113 feet high and 30 feet in diameter, with a volume of 78,000 cubic feet, which was filled with farmers stock peanuts. Plastic tubes were placed at different depths and locations in the silo to sample for carbon dioxide and oxygen concentrations. The carbon dioxide was pumped from a tank truck into the top of the silo. A uniform concentration of 35% carbon dioxide and 14% oxygen was obtained and maintained for 7 days. Laboratory studies had shown these concentrations were effective against many stored-peanut insects. The cost of the gas for a 4-day treatment period was estimated to be slightly more than ½ cent per bushel, a cost competitive with fumigation, but a treatment that leaves no residue. Tests were also conducted in a wooden bin of farmers stock peanuts, lined on the floor, sides, and top with a 12-mil plastic film. Gas analyses revealed good distribution and concentration of carbon dioxide soon after application was completed, but the desired concentration could not be maintained in the bin. (MQ 1-60)

When the almond moth was reared at 27° C. and 60% relative humidity, the life cycle from egg to adult averaged 23.2 days on a laboratory culture medium but required 10.3 days longer on shelled Spanish peanuts. The life cycle of the Indian-meal moth was 1.3 days shorter on the culture medium and 2.1 days shorter on Spanish peanuts. (Exploratory)

Observations were made in farmers stock peanut warehouses at 12 random locations on insect infestations and effectiveness of present control recommendations. There were moderate to heavy moth infestations in some warehouses and very few moths in others. The heavy populations were in warehouses where the malathion surface treatments were not applied adequately. The almond moth was the prevalent species and only 2 warehouses had infestations heavy enough to web over surface areas. Insect damage at load-out was reported to be minor. The first few loads where there was heavy surface infestation had 1 or 2% "worm cut" damaged kernels and the remainder usually averaged less than 0.2% insect damage.

Nine strains of almond moths were collected to determine the degree of malathion resistance. Some of the warehouses have used the malathion treatment for 7 storage seasons. The LD₅₀ malathion dosages ranged 9 to 13 times higher than for the standard laboratory strain, about a 3-fold increase over the previous storage season. (Unclassified)

The almond moth and red flour beetle continue to be the prevalent insects in peanut shelling plants. Light trap catches were heaviest from May through September with a peak in August, and were lightest in January and February. Dissection of 1,800 female almond moths from trap catches showed that 99.6% had mated. Examination of the fat body showed the majority of the moths were several days old before they were caught in the traps. (Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling, Drying and Storage

Taber, R. A. and H. W. Schroeder. 1967. Aflatoxin-producing potential of isolates of the Asperigillus flavus-oryzae group from peanuts (Arachis hypogaea). Applied Microbiology 15: 140-144. (MQ 2-103)

Schroeder, H. W. 1966. Effect of corn steep liquor on mycelial growth and aflatoxin production in Aspergillus parasiticus. Applied Microbiology 14: 381-385. (MQ 2-103)

Prevention of Insect Infestation

Anonymous. 1966. Nitrogen kills flour beetles. International Pest Control 8 (6): 4. (Based on article by Press and Harein 1966.) (MQ 1-60)

Jackson, Curtis R., and Arthur F. Press, Jr. 1967. Changes in mycoflora of peanuts stored at two temperatures in air or in high concentrations of nitrogen or carbon dioxide. Oleagineux 22 (3): 165-168. (MQ 1-60)

Laudani, H., and A. F. Press, Jr. 1966. Control of stored-peanut insects by atmospheric gases. Proceedings, Papers, and Addresses, Fourth National Peanut Research Conference, Tifton, Georgia, July 14-15, 1966, pp. 86-87. (MQ 1-60)

USDA, ARS Information. 1966. Gases kill storage insects. Agricultural Research 15 (2): 7. (Based on article by Press and Harein 1966.) (MQ 1-60)

AREA 7

COTTON AND COTTONSEED - MARKET QUALITY

Problem. Technological advancement in production, harvesting and ginning of cotton brought on by mechanization has resulted in changes in the quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting and ginning practices in preparation for market. New and improved techniques, devices and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading and standardization programs.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, chemists and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C.; Lubbock, Texas; and Clemson, South Carolina, in cooperation with Clemson University and by research contracts with Texas Technological College and with commercial firms.

The Federal scientific effort devoted to research in this area totals 15.7 scientist man-years subdivided as follows: cotton, 13.1, with 6.1 under research contract, and cottonseed, 2.6.

The program includes the following foreign project under P.L. 480: A grant to the Regional Research Laboratory, Division of Oils and Fats, Hyderabad, India, provides for a study on mycotoxins in cotton and covers a preliminary survey of the growth of Aspergillus flavus and the production of aflatoxins in cottonseed. Its duration is for 3 years (1967-70) and involves P.L. 480 funds of \$17,223.85 equivalent in Indian rupees.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 6.6 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurements and evaluation of quality of cotton

1. Effect of Various Production, Harvesting and Ginning Practices on Cotton Quality and Spinning Performance. Results of individual studies are summarized as follows:

(a) 1964 Humidification and Storage Study. The effects on fiber properties, spinning performance and product quality of cotton stored in warehouses at three levels of humidification and for different storage periods were evaluated. As humidity level increased or as storage time lengthened, the cotton color increased in yellowness. Preliminary analyses of fiber and spinning test results indicate that other fiber properties, spinning performance and product quality were not affected by the humidity levels or storage times used in this study.

(b) 1965 Color and Trash Study. The effect on spinning performance and product quality of cotton was determined for varying color levels caused by field weathering in combination with varying foreign matter levels in ginned lint. Late harvest caused a deterioration in fiber and spinning quality.

(c) 1965 Southeastern Picker-Stripper Study. Fiber and spinning quality of stripped Clemson cotton was better than second machine-picked but not as good as first machine-picked cotton. However, the fiber and spinning quality of stripped Auburn cotton was not as good as first or second machine-picked.

(d) 1965 California Gleaning Study. Fiber and spinning quality of cotton gleaned from the ground was inferior to machine-picked cotton from the cotton plant. Compared with machine-picked cotton, the gleaned cotton was less uniform in length and had lower fiber strength, thus causing the yarn to be weaker and causing more spinning end breakage.

(e) 1965 Reclaimed Gin-Loss Study. This study was designed to determine the effects of reclaimed cotton fiber normally lost in the lint cleaning process upon spinning performance when blended back into the original bale. Test results showed no significant differences for product quality and spinning performance; however, waste content for control cotton was significantly less than for cotton which had reclaimed fibers blended back into the bale.

(f) 1966 Chemical Additive Study (X-78). Preliminary results showed no significant effects of the additive on fiber and yarn quality or on processing and finishing performance when the additive is applied at recommended rate (0.15% by weight).

(g) Roller Gin Study. A study of possible causes for certain Acala 1517 cotton to lap when roller-ginned but not when saw-ginned was made. Results showed that (1) a walrus-covered roller did not cause a significant number of lap ups, and (2) a rubber-covered roller, in conjunction with high operating temperature, caused Acala 1517 cotton to lap very badly during spinning. Chemical tests made on these cottons did not reveal what caused the lapping in the cotton fiber. Further investigations are being made on the 1967 cotton crop. (MQ 3-33)

2. Investigation of Chemical Residues on Surface of Cotton Fibers. The causes of certain cottons to stick and lap to rolls were studied. Several distinct factors contribute to sticking and lapping: (1) low micronaire value in combination with high sugar and non-cellulosic content; (2) contamination, such as by lubricating oils; and (3) excessive amount of broken seeds. These conditions, either alone or in combination account for much of the fiber sticking and lapping that occurs. (MQ 3-42)

3. Measurement of Frictional Properties of Cotton Fibers. Improvements have been made in the instrumentation used to measure low levels of drafting force and drafting variability in normal spinning draft mechanisms. Measurements of drafting force and drafting-force variability on a wide selection of cotton rovings indicate that these force measurements are practical and can be used to improve cotton yarn quality through the exercise of closer control of the drafting force actions in the spinning frame. (MQ 3-43)

4. Instrument Evaluation. CPI-SRI Strength Tester: Studies made of the working principles of this apparatus showed (1) its testing error C. V. was more than twice as great as that of Pressley tests; (2) testing error C. V. varied between samples; (3) density readings made by the light photocell system seemed to measure bundle size accurately within each sample; (4) fineness affected the photocell system's measurements of bundle size; and (5) correcting the CPI-SRI strength indexes for the effect of micronaire readings improved their relationship to break factor, but not sufficiently to equal that of Pressley and break factor. Motion Control Length Analyzer: When range of length was great, the prototype Motion Control Air Device gave better 3% span length measurements than the Length Analyzer, but for 30% span lengths on these samples and for the same two measurements on samples where length varied little, one instrument was as good as the other. The Length Analyzer is a more rapid tester, both in beard selection and in measuring. Better results were obtained when samples were not held during clamp loading.

Length Analyzer 3% span lengths were only half as efficient tests as Digital Fibrograph 2.5% span lengths for both ginned lint and card web. One-fourth as much cotton is tested for one measurement by Length Analyzer as is used for Digital. Even when comparing measurements of equal amounts of fiber beard, Digital 2.5% span lengths were superior to Length Analyzer 3% span lengths. Length Analyzer 30% span lengths were half as efficient as Digital 50% span lengths when testing card web, but there was no appreciable difference between instruments when testing ginned lint. For equal amounts of fiber beard, the Length Analyzer 30% span length was better than the Digital 50% span length.

Both Length Analyzer and Digital Fibrograph tests made on card web were more efficient than those made on ginned lint for the same cottons.

The Fibrosampler technique for selecting a specimen seems to be better than the Length Analyzer's clamping technique, as far as the 3% span length is concerned, but the reverse is true for the 30% span length. (MQ 3-47)

5. Development and Evaluation of an Instrument and Techniques for Rapid Determination of Cotton Fiber Strength. A specimen system for preparing a test beard was developed to measure a predetermined cross-sectional area at which to clamp and break the test beard for strength measurement. (MQ 3-71(c))

6. Methodology Studies for Development of Spinning Performance Tests for Cotton. The status of progress based on results of research are summarized below:

(a) 1964 California Fiber Properties Study. Small differences in fiber length characteristics affected spinning test results.

(b) 1965 Methodology-Micronaire Study. As the micronaire reading decreases, the cradle opening at spinning should be increased slightly. No interactions seem to exist between micronaire fineness and spindle speed or twist multiplier in reference to the effects of fineness on spinning performance.

(c) 1965 Fiber Properties Study. Staple length and fiber fineness affected spinning production rate, whereas classer's grade and fiber strength did not.

(d) Methodology-Carding Variables Study. Spinning performance of Acala cotton was affected very little by card production rates or by cylinder and licker-in speeds within the ranges used. Spinning performance of Deltapine cotton was affected by these variables but not consistently.

(e) 1966 Spinning End Breakage Study. On the average, the current formula for correcting end breakage to nominal yarn size undercorrects end breakage for yarn size differences. However, some of the trends were inconsistent; hence, more study is needed.

(f) Methodology-Spinning Parameters Study. Results indicate that for 30s yarn the cradle opening at spinning should not be the same as for 40s yarn. (MQ 3-73)

7. Development of an Instrument for Rapid Determination of Cotton Color and of Trash Content Separately in a Sample of Cotton. The final phase of this work has been completed and the instrument will be shipped to the Cotton Quality Research Laboratory at Clemson, South Carolina, for extensive evaluation tests. (MQ 3-81(C))

B. Objective measurement of quality of cottonseed

1. Method for the Rapid Measurement of the Refining Loss of Cottonseed Oil in Small Lots of Seed. Glassware redesigned for use in neutral oil determinations is now undergoing field testing by the Neutral Oil Committee of the American Oil Chemist's Society. This glassware modification should materially reduce the cost of this test as well as improve its efficiency. The modified neutral oil test using regular glassware was developed in our laboratory and field tested by the same committee the past year and found to have 25% greater accuracy over the old method. The method is now official with the AOCS and was used during the past year by the National Soybean Processors Association in soybean oil trading. (MQ 3-45)

2. Reevaluation and Improvement of Official Cottonseed Standards for Reflecting More Accurately the Value of Products Obtained from Cottonseed. A study of the optimum sample size and greatest amount of cottonseed which may be represented by a sample under conditions now existing at oil mills was conducted in cooperation with the Cotton Division and Statistical Staff, Consumer and Marketing Service. This study proved that the sample size could be increased from 60 tons to 100 tons. The number of probes in each lot was reduced from 5 to 2 probes. A set of probe cards, for use in sampling, are being provided all licensed samplers for use with the 1967 crop. This development will materially decrease the cost of sampling cottonseed at oil mills. (MQ 3-51)

3. Effect of Storage on Molds and Aflatoxins in Cottonseed. The third year of a survey for the presence of aflatoxins was completed with 54 cottonseed oil mills cooperating. More than 1,000 samples of cottonseed and a like number of meal samples were assayed. During this period, nearly nine out of ten meal samples were free of aflatoxins as compared with four out of five during the two previous years. In each year of the survey, nine out of ten cottonseed samples indicated no aflatoxins. Further investigations indicated that contamination with aflatoxins was concentrated in a small number of seed in a given lot.

No aflatoxins have been found in hulls from contaminated seed. No correlation has been found between free fatty acids and aflatoxin content of cottonseed. (MQ 2-108)

C. Quality maintenance in handling and storage

1. Molds and Aflatoxins in Cottonseed. Several lots of cottonseed, ginned by the Southwestern Ginning Laboratory, were experimentally stored under conditions of high relative humidity and at optimum temperatures for the production of aflatoxins. Type of gin (roller or sawtooth) could not be associated with the subsequent development of aflatoxins. The aflatoxin content of the cottonseed remained without significant change during the first 10 days but significant amounts were detected in all samples after 20 days. Internal infection by Aspergillus flavus remained at about the

same prevalence throughout these experiments. The only significant change in the internal flora of the seed was a large increase in the percentage of seeds infected by A. glaucus spp. accompanied by an equal decrease in the percentage of mold-free seeds. (MQ 2-115)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

LaFerney, Preston E., Robert A. Mullikin and Charles S. Shaw. 1966. Spinning quality of cotton as affected by gin cleaning, card crusher rolls and varying carding rates, Mississippi, 1965-66 season. MRR No. 778, ERS-ARS. (MQ 3-33 Rev.)

Mullikin, Robert A., Preston E. LaFerney, and Franklin E. Newton. 1966. Effect of certain carding variables on cotton spinning performance and yarn quality. Presented at the TQCA Meeting, Asheville, N. C., September 1966 and published in Textile Bulletin, pp. 34-38. (MQ 3-73)

Carpenter, Frances. 1967. Evaluation of the fibrosampler and the digital fibrograph for measuring length and length distribution of cotton fibers. MRR No. 775. (MQ 3-47)

Griffin, A. Clyde, Preston E. LaFerney and Henry H. Perkins, Jr. 1967. The effect of chemical ginning aids on cotton quality, processing and gin operation: A progress report. Presented at Mid-South Ginners Convention, Memphis, Tennessee, March 1967. (MQ 3-42)

LaFerney, Preston, E., Henry H. Perkins, Jr., and A. Clyde Griffin. 1967. Effects of applying a chemical additive to cotton during ginning. Paper presented at the 18th Annual Cotton Research Clinic, Pine Mt., Georgia, February 1967. To be published in future issue of Textile Bulletin. (MQ 3-42)

Newton, Franklin E. and Samuel T. Burley, Jr. 1967. Cotton fiber quality factors and relationships to processing. Paper presented at the 19th Annual Cotton Improvement Conference, Dallas, Texas, January 1967. (MQ 3-33 Rev.)

Newton, Franklin E., Samuel T. Burley, Jr., and Edward H. Shanklin. 1967. Factors influencing the quality of cotton and yarn in relation to manufacturing efficiency. Presented at the Extension Specialist's Cotton Quality Conference, Greenville, South Carolina, May 1967. (MQ 3-73)

Shanklin, Edward H., Preston E. LaFerney and Warren E. Garner. 1967. Cotton color as related to other quality factors, 1965-66 crop year. Presented at the 18th Annual Cotton Research Clinic, Pine Mt., Georgia, February 1967. To be published in future issue of Textile Bulletin. (MQ 3-33 Rev.)

AREA 8

WOOL AND MOHAIR - MARKET QUALITY

Problem. Wool fineness, variability, and color are the most important quality characteristics in determining the grade and consequently the economic value of wool. However, present methods of determining wool fineness and variability are slow and tedious and the causes of yellow coloration of raw wools are not known. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used for mothproofing wool has been questioned, and safer effective treatments are needed.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program for quality evaluation of wool involving (1) the study of the relationships of fineness, softness and quality of domestic wools; (2) development of rapid methods for the preparation of cored wool for determination of fineness and variability of fineness; and (3) determination of the causes and prevention of canary yellow coloration in raw wools. Work is in progress at Beltsville, Maryland, University of Wyoming, and Shri Ram Institute for Industrial Research, Delhi, India. The research in India is a 5-year program, 1963-68, being carried out under a P.L. 480 grant of \$92,536 equivalent in rupees. The Federal effort devoted to research in this area of quality evaluation is 1.1 scientist man-years of which 1.0 is on contract research.

There is also a continuing Department program headquartered at Savannah, Georgia, involving applied research in entomology and chemistry, directed toward the protection of wool, mohair, and other animal fibers against insect damage, with special emphasis on the development of nontoxic mothproofing treatments. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A 2-year contract with the Harris Research Laboratories, effective in June 1966, is for research to develop commercial procedures for applying quaternary ammonium compounds as mothproofing treatments.

The Federal effort devoted to research on the protection of wool and mohair against insect damage was 1.6 scientist man-years, of which 0.6 was under research contract. Some of the cross-commodity research reported in

Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool and mohair.

Line Project MQ 1-49(C), a study of the physical and chemical factors affecting the sorption and retention of quaternary ammonium mothproofing compounds by wool, was terminated in April 1967 after completion of the contract.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 2.3 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Sample Preparation of Wool for Fineness Determination by the Coulter Counter Technique. A rapid method has been developed for the preparation of specimens of wool tops and grease wool cores for fineness analyses in the Coulter Counter. Grease wool core preparation includes detergent cleaning and scouring of the sample followed by hand carding. (MQ 3-69(C))

2. Interrelationships of Wool Fineness, Softness Quality and Market Evaluation of Domestic Wools. Objective methods for the evaluation of softness of bulk wool samples are being developed. One method showing promise is the measurement of the amount of work required to compress a pad of wool using a plate attached to an Instron Tensile Tester. Repeated compression/recovery cycles have indicated that compression loads in the range of 0 to 50 grams appear to yield the most precise estimate of softness. (MQ 3-92(C))

3. Canary Yellow Coloration of Raw Wool. Isolation and characterization of pigments from canary yellow stained wools have shown that pyrrole, amino, phenolic, carbonyl and unsaturated chemical groups are present. Test results on canary yellow stained fleeces showed that the yellow staining was much less severe in the United States wool than in wool from India. United States canary yellow stained fleeces have a higher grease content, higher suint content and a lower pigment content in the wool fibers than do Indian wools. (A7-AMS-12)

B. Prevention of insect infestation

1. Nontoxic Mothproofing Treatments. Of the 38 compounds given preliminary evaluation as mothproofers, 5 were found promising because of performance and low mammalian toxicity. Their oral LD₅₀ for rats ranges between 1,000 and 4,640 mg. per kg. (MQ 1-26)

The Eastern Utilization Research and Development Division worked out a method for tanning with gluteraldehyde the shearlings used for hospital bed pads. Since the gluteraldehyde combines chemically with the keratin in the wool and forms strong cross links, it was hoped the treatment might also provide mothproofing properties to the wool. Bioassay tests revealed that the treated wool was not protected against feeding by the black carpet beetle. (MQ 1-26)

Practical studies with a quaternary ammonium compound showed that this material could be applied in a home type washer to provide an effective mothproofing treatment. Application in a commercial type textile padder was not so effective, probably because there was mostly surface deposition rather than thorough impregnation of the fabric. Desorption studies conducted with radioactive forms of four quaternary ammonium compounds, conducted under selected laundering and drycleaning conditions, showed that all four were removed more readily by laundering with soap and detergents than by drycleaning. (MQ 1-49(C))

Studies with 23 compounds representing quaternary ammoniums with short or intermediate length alkyl chains, dimethyl benzyl lanolinamido ammonium chlorides, a pyridinium chloride, and several alkylamines, showed that a quaternary ammonium compound with eight-carbon alkyl chains was highly effective against both carpet beetles and clothes moths at deposits on wool of 12 to 30 times less than for other quaternary ammonium compounds previously tested. (MQ 1-61(C))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

- Buras, Jr., E. M., J. A. Penoyer, Sr., and K. E. Hoke. 1967. Cutting wool fibers for electronic particle size analysis. Proc. Fiber Society. Asheville, North Carolina. May (Abstract) (MQ 3-69(C))
- Chipalkatti, H. R., A. D. Sule, K. K. Juneja, and M. C. Aggarwal. 1965. Some observations on canary coloration in Indian raw wools. Journal of the Textile Institute 56(12). (A7-AMS-12)
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Prevention of Insect Infestation

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AREA 9

POTATOES - MARKET QUALITY

Problem. The increased demand for potatoes to be used for chips, frozen french fries and other processed forms has created special problems of preventing undesirable chemical changes due to low temperatures during storage and transport. The use of higher temperatures has brought on additional problems of moisture loss, internal black spot, and of bacterial and fungal decay. Higher temperature storage also calls for control of sprouting, with increased emphasis on sprout inhibitors. Objective indices are needed to identify quality factors that are important for specific product usage and relate measurable characters of the raw product to quality of the processed product. Also needed are instruments for non-destructive detection and rejection of potatoes with internal disorders during grading.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota, is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine, is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips and modified atmospheres is conducted by the Fresno, California station. The studies at Beltsville involve quality evaluation, storage environments, and basic research. Studies on market diseases are conducted at Chicago and Belle Mead, New Jersey.

The Federal effort devoted to research in this area totals 5.0 scientist man-years. Of this number 0.5 is devoted to quality evaluation; 0.7 to quality maintenance in handling and packaging; 1.7 to quality maintenance in storage; 0.9 to quality maintenance during transportation; and 1.2 to post-harvest disease control.

Projects terminated during this period included: Transit temperatures of California potatoes (MQ 2-55) and Storage temperatures for processing potatoes (MQ 2-69)

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 7.0 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Color Measurement in Potato Chips. Potato chips, ranging in color from very light yellow to very dark brown, were measured objectively with 3 different instruments and subjectively by several observers. The results indicate that potato chip color can be satisfactorily measured with a variety of instruments. Correlation coefficients between many color parameters of potato chips and panel scores were highly significant, and exceeded that required for prediction purposes. The Photovolt Reflection Meter with tristimulus green filter is the most economical of the instruments used. For more precise measurements, fluorescent and light scattering need to be evaluated. (MQ 3-97)

2. Susceptibility of Tubers to Bruising. Results of tests indicate a linear dependence of the elasticity of potato tissue on turgor pressure within the potato. The basis for a rapid measurement of turgor pressure differences within potatoes was provided by determining the elasticity with a device measuring sound vibrations within the tissue. Mechanical bruising and turgidity were significantly and directly correlated. Irrigation prior to harvest increased turgidity while root pruning decreased turgidity within the tubers. Vine removal 4 days before harvest did not significantly influence turgidity at harvest. (MQ 3-40)

B. Quality maintenance in handling and packaging

1. Stone Separation by Water. Potatoes of the Russet Burbank and Kennebec varieties that were subjected to a water flume-stone trap before storage in pallet boxes at 45° and 55° F. showed no injury to tuber quality after 5 months' storage. Flumed seed potatoes shipped by rail to northern West Virginia arrived in excellent condition except for some freezing damage incurred during transit.

Seed potatoes, pre-cut in January after washing and chemical or heat treatments, averaged 97% stand as compared with 75% stand for seed planted immediately after cutting. The increased stand from pre-cut seed was due to control of black-leg and seed-piece rots. Potatoes of two varieties, Russet Burbank and Kennebec, remained in excellent condition for 2 months after being pre-cut, treated with Polyram dust, and stored in bulk bins before planting. (MQ 2-93)

C. Quality maintenance in storage

1. Effect of Periods and Rates of Ventilation on Quality of Maine Potatoes. Intermittent forced-air ventilation of potatoes stored in bulk bins at 55° F. for processing effectively controlled Fusarium tuber-rot and soft rot. Pressure bruising was increased in the ventilated bins. When ventilated 12% of the storage period, the amount of pressure bruising was doubled over the non-ventilated control. Approximately four times as much pressure bruising

occurred in bins with forced air ventilation for 25% and 50% of the storage period as in the non-ventilated check. Ventilation at approximately 3 cfm/cwt. dried up artificially induced field frost injury in bulk bin storage in about 2 months.

No internal defects and very little surface mold developed on Katahdin or Kennebec potatoes when storage at 32° F. was interrupted by periods of one week at 60° so that the longest continuous time at 32° was 3 weeks. After 19 weeks, tubers at 32° with 60° interruptions were comparable in internal and external appearance to tubers stored continuously at 36° or 40°. Respiration rates measured at 60° F. one day after removal of tubers from storage, were about $\frac{1}{2}$ as high for those shifted from 32° to 60° periodically as for tubers at 32° continuously. Respiration rates were similar for shifted tubers and those at 36° or 40° continuously. Total and reducing sugar content of the shifted tubers followed a pattern similar to respiration rates.

Before storage, cut surfaces of tubers had a bluish-white fluorescence under ultra-violet light. After 11 weeks at 32° F. a bright yellow fluorescence often was seen in areas where mahogany browning or blackheart occurred. This type of fluorescence did not appear in tubers stored at 32° with intermittent storage at 60° or those stored at 36° and 40°. This fluorescent material is being identified. (MQ 2-92)

D. Quality maintenance during transportation

1. Low Oxygen Atmospheres. Potatoes held for 8 days in $\frac{1}{2}$ or 1% O₂ at 68° or 59° F. were injured severely. Most of the tubers held in low O₂ were decayed and/or had black heart, whereas nearly all those held in air or 5% O₂ were sound. Both low O₂ atmospheres prevented periderm formation and inhibited recovery even after removal of the tubers to air. Five to 10% decay developed when the tubers held in $\frac{1}{2}$ or 1% O₂ at 41° were subsequently held for 8 days in air. (MQ 2-136)

E. Postharvest disease control

1. Hot Water Treatment of Seed Potatoes. Hot water dips severe enough to cause tuber breakdown failed to eradicate spindle tuber or leaf roll viruses in infected tubers. A 5-minute dip in 130° water was as effective as Semesan bel in controlling Rhizoctonia stem-canker and seed piece rots. The best time-temperature conditions for disease control and overall seed quality was 5 - 7 minute dips in 130° water. Tissue breakdown occurred when tubers were soaked for more than one minute at 135°. Soft rot followed and no sprouting occurred. In general, non-injurious hot water dips accelerated sprouting and resulted in early emergence and more uniform stands. In some cases, yields were increased from treated B-size seed. (MQ 2-90)

2. Market Losses in Potatoes. Maine Katahdin potatoes showed an average of 1.5% loss at wholesale in the New York City market, principally from mechanical injuries. Retail losses were very slight because almost all were sold

prepackaged. Trimming losses averaged about 3.5% at the consumer level. Most of this loss was due to Fusarium rot, physiological disorders, and cuts and bruises.

In the Chicago market average losses in Red Pontiac potatoes from the Red River Valley were 3.4% at wholesale, less than 1% at retail, and slightly more than 4% at the consumer level. (MQ 2-132)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance During Handling and Packaging

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Johnston, E. F. and J. B. Wilson. 1966. Soil, air, and tuber temperatures and bruise resistance. Maine Agr. Expt. Sta. Misc. Rpt. 119. (MQ 2-93)

Quality Maintenance During Storage

Hruschka, H. W. and P. H. Heinze. 1967. External and internal sprouts in potatoes dipped in low concentration CIPC-water emulsions. Amer. Potato Jour. 44(2):51-55. (MQ 2-130)

Wilson, J. B. 1967. Pressure bruising and internal black spot /Maine/ Potato Councillor. (April) (MQ 2-92)

Wilson, J. B. 1966. Shrinkage of potatoes in storage and its causes. Proc. Natl. Potato Util. Conf. ARS 74-40, p. 29-37. (MQ 2-92)

Wilson, J. B. and E. F. Johnston. 1966. Salvaging field-frosted potatoes. Maine Farm Res. 14(3):31-34. (MQ 2-93)

Wilson, J. B. and R. L. Todd. 1966. Removing Chloro-IPC residues. Maine Farm Res. 14(3):54-56. (MQ 2-130)

Postharvest Physiology

Craft, C. C. 1966. Salt hardness and dye reduction by potato tissue and mitochondrial fractions as influenced by previous storage of the tubers. Plant Physiol. 41:1662-1666. (Pioneering Laboratory)

Craft, C. C. 1967. Respiration of potato tissue as influenced by previous storage temperature of the tubers. Amer. Potato Jour. 44:174-181. (Pioneering Laboratory)

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AREA 10

POULTRY PRODUCTS - MARKET QUALITY

Problem. Technological developments continue in the poultry industry and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized and wholesome products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. This research is conducted at Beltsville, Maryland, Athens, Georgia and through research agreements and contracts with Iowa State University, Ames, Iowa; the University of Delaware, Newark, Delaware; and Oklahoma State University, Stillwater, Oklahoma.

A P.L. 480 grant was made to the Centro Experiment del Frio, Madrid, Spain, for a study of changes occurring in egg whites during cold storage. Its duration is for 3 years (1964-67) and involves P.L. 480 funds with a \$26,370 equivalent in Spanish pesetas.

The Federal scientific effort devoted to research in this area totals 4.8 scientist man-years; objective measurement and evaluation of quality, 3.8, and handling, packaging and storage, 1.0.

The line project "Determination of lighting and other visual environmental requirements for proper grading and inspection of poultry" was terminated during this period. (MQ 3-52)

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 12.9 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Detection of Salmonella in Poultry and Egg Products. The technique for screening Salmonella-negative samples of dried egg was refined, including construction of a special glass flask with three side-arm tubes. Mannitol purple agar and SIM agar, can be added directly to the tubes so that these media are in contact with the lactose pre-enrichment broth in the main part of the flask. Selenite-cystine or tetrathionate can be added to the third tube thus facilitating isolation of bacteria in the event of a positive reaction in either the MP or SIM tubes. A study was initiated to compare various pre-enrichment ("primary enrichment") media in combination with various enrichment ("secondary") media for recovery of salmonellae in egg products. (MQ 3-74)

2. Lighting Requirements for Proper Inspection of Poultry. A study of the effect of quality and intensity of light in judgment of colors encountered in poultry inspection was completed. Four types of fluorescent lamps, both alone and supplemented with two types of incandescent lamps were evaluated at 50 and 100 foot-candles intensities. Twelve observers made 25,920 judgments of paired color chips that represented colors of importance in post-mortem inspection of poultry carcasses. Significantly fewer errors (color chips actually alike judged to differ) were made at 100 than at 50 foot-candles. The type of light sources or combinations had no significant effect on the number of incorrect judgments. (MQ 3-52)

3. Detection of Pesticide Residues in Poultry and Egg Products. Work was continued to improve the thin-layer chromatographic technique for detection of chlorinated hydrocarbon pesticide residues in poultry and egg products. Cleanup of rendered chicken fat was improved by employing a column of smaller diameter and greater length which aided in retention of the fat. Changes in volume or concentration of some of the reagents and modification of thin-layer plates are being used to develop a more rapid technique. The modifications also appear to contribute to a more accurate determination of pesticide with very low RF values, e.g., methoxychlor. (MQ 3-70)

B. Quality maintenance in handling, packaging and storage

1. Quality of Chicken Fryers During Holding in Various Shipping Containers. Determinations were made of bacterial counts, changes in carcass and box weights, and degree of ice retention in wirebound crates, and corrugated fiberboard (wax impregnated) and polystyrene boxes during holding of ready-to-cook chicken fryers at various temperatures for periods up to 2 weeks. After 24 hours at 23.9° or 31.1° C., fluid drainings from wirebound crates packed with 9.1 kg of ice had higher bacterial counts than fluid from fiberboard and polystyrene boxes with 9.1 kg of ice. Breast skin bacterial counts were higher on chickens in wirebound crates than in polystyrene boxes with either 9.1 or 6.8 kg of ice over 13 days of storage at 4.4° C. Chickens in

fiberboard boxes with 9.1 kg of ice exhibited higher bacterial counts than those in polystyrene boxes with 9.1 kg of ice during 13 days of storage at 4.4° C. A greater percentage of ice was lost in wirebound crates than in fiberboard boxes, and the loss in fiberboard was greater than in polystyrene boxes, during 6 day storage at 4.4° C. Weight loss of carcasses in wirebound crates was higher than those in fiberboard or polystyrene boxes during the same period. This work was carried out in cooperation with the Transportation & Facilities Research Division, ARS. (Exploratory)

2. Frozen Poultry Shipments to Europe. Research on effect of packing and boxing techniques on quality and condition of frozen poultry shipped to European markets by refrigerated van container was conducted in cooperation with the Transportation & Facilities Research Division, ARS. Light weight boxes were adequate and no strapping of boxes was required to protect the product for van container shipments. Temperature control and reliability were satisfactory. (Exploratory)

3. Shelf Life of Chickens Packed in Carbonated Ice. Eviscerated fryer chickens packed with carbonated ice in conventional wirebound or fiberboard shipping containers did not differ significantly in bacterial condition from those packed with ordinary water ice during storage for 11 days at 1° C. (Exploratory)

4. Post Chill Washing of Fryer Chickens. In an in-plant study, spray washing of fryer chickens with a commercial type washer shortly after chilling with or without chlorine (10, 20 and 50 ppm) did not significantly reduce the total bacterial count or the numbers of psychrophiles on the skin surface. (Exploratory)

5. Microbiology of "Further Processed" Turkey Products. "Further processed" turkey products prepared from chilled eviscerated carcasses at two commercial turkey processing plants were analyzed for salmonellae, coagulase positive staphylococci and total aerobes. Salmonellae were isolated from swab samples from 14% of chilled carcasses, 27% of raw finished products (uncooked) and 24% of processing equipment. The same serotypes as those found throughout the plant on any one visit were recovered from 31% of rinse samples taken from hands and gloves of processing personnel. Salmonellae were found in samples taken on 37 of 48 visits; a greater number of recoveries being made on days when freshly killed turkeys were processed (87%) than when frozen defrosted carcasses were processed (59%). Salmonella san diego and Salmonella anatum were predominant among the 23 serotypes recovered. Staphylococcus aureus was recovered from about 60% of swab samples of the surface of raw rolls, but no recovery was made from the cooked rolls. Ingredients contained no coagulase positive staphylococci and less than 300 aerobes per gram. Throughout evisceration and further processing, an important source of staphylococci was worker's hands. These studies are being conducted at Iowa State University under contract. (MQ 2-113(c))

6. Chemical Changes in Broiler Carcasses During Refrigerated Storage. Infrared spectrophotometric evaluation of skin surface lipids of chicken broiler carcasses revealed a progressive increase in the ratio of transmittance at 6.1 microns to that at 3.4 - 3.5 microns as storage time increases. A leveling off of the ratio coincided approximately with the onset of spoilage off-odors. (Exploratory)

7. Changes Occurring in Egg White During Storage. Physical and chemical determinations were made on water thermostabilized (60° C. - 4 minutes) and untreated shell eggs stored at 0° and 15° C. for periods up to 9 months. Shell eggs held in a 4.5% CO₂ atmosphere at 0° C. were also included in the study. All eggs were maintained at 85 to 90% relative humidity. Thermostabilized eggs exhibited a greater weight loss during storage than the other groups. At 0° C. weight loss of CO₂-held eggs was greater than that of untreated eggs. Formation of thin white was lowest in thermostabilized eggs; at 0° C., percent thin white of these eggs showed the least variation throughout storage. CO₂-held eggs showed the greatest increases in percent thin white. Electrophoretically, lysozyme appeared to form two complexes during storage; one anionic - possibly conalbumin and lysozyme and one cationic-lysozyme and ovomucin. The lysozyme and ovomucoid fractions disappeared during storage at 15° C. but only a slight regression of these components was noted in eggs stored at 0° C. The free amino acid content of the white of all eggs increased with storage; alanine, valine, methionine and glutamic acid were found most often. (E25-AMS-8(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Banwart, G., A. J. Mercuri and T. Ryan. 1966. Screening method for Salmonella-negative samples of dried egg (Abstract). Poultry Sci. 45(5): 1067-1068. Also presented at Poultry Science Association Meeting at Logan, Utah, August 16, 1966. (MQ 3-74)

Moats, W. A. and A. W. Kotula. 1966. Single step cleanup of chlorinated pesticide residues, using high elution rates. Jour. Assoc. Offic. Anal. Chem. 49(5): 973-975. (MQ 3-70)

Quality Maintenance in Handling, Packaging and Storage

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Kotula, A. W. and N. V. Helbacka. 1966. Blood volume of live chickens and influence of slaughter technique on blood loss. Poultry Science 45(4): 684-688. (MQ 2-81)

- Mercuri, A. J., A. W. Kotula and D. H. Sanders. 1966. Low dose ionizing irradiation of tray-packed cut-up fryer chickens. Poultry Science 45(5): 1105. (Abstract)
- Taylor, M. H., N. V. Helbacka and A. W. Kotula. 1966. Evacuated packaging of fresh broiler chickens. Poultry Science 45(6):1207-1210. (MQ 2)
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- daSilva, G. A. N., A. A. Kraft and J. C. Ayres. 1967. The occurrence of Staphylococcus aureus in cooked and uncooked turkey rolls. Bact. Proc., p. 12. (MQ 2-113(c))

AREA 11

TOBACCO - MARKET QUALITY

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program continues to cause a large buildup of stocks, some held about twice the normal period for aging and storage. The long-term storage and the compact, dense structure of the tobacco in the storage hogsheads make insect control difficult. Repeated, heavy applications of fumigants and insecticides during storage has raised questions about the amount, nature, and significance of residues that may accumulate. Treatments applied during storage should be investigated in greater depth to be sure they are safe. Problems associated with tobacco fumigation in commercial channels have become acute during the past year. It was found that insect kill at the interior of hogsheads was less than anticipated. There were also some injuries to workers exposed to gas coming out of insufficiently aerated hogsheads. It is imperative that safe, effective procedures be developed. The advent of containerized shipping of export tobacco brings up new problems of insect control, particularly of fumigation. It is necessary to find the amount and rate of gas penetration and aeration in the large 20- by 40-foot metal containers. Attention should also be given to developing procedures for preventing or controlling insect infestations by means that will minimize or eliminate the use of toxic chemicals. To accomplish this it will be necessary to develop much more basic information on the ecology, physiology, and behavior of the insects that attack stored tobacco. Various fungi, bacteria, and viruses are found in tobacco. It is becoming quite apparent that the quantity of phenolic compounds is increased markedly in diseased plant tissue, including tobacco leaf. These substances may affect mammalian physiology. Research is needed to determine the changes that occur in the composition of tobacco leaf as the result of the metabolic activities of pathogens and to characterize the organisms that constitute the nonpathogenic microflora associated with tobacco leaves.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program headquartered at Richmond, Virginia, involving basic and applied research in entomology, directed toward the insect problems of tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department. The Federal effort devoted to this program is temporarily only 1.0 scientist man-year because of the inability to find

qualified personnel to fill two vacancies. Some of the cross-commodity research reported in Area 13, "Insect Control in Marketing Channels," applies to the insect problems in stored tobacco.

Line Project MQ 1-37, a study of flowing steam under vacuum to control tobacco insects, was terminated April 19, 1967.

The Department is conducting quality research at Raleigh, North Carolina, and under contract and cooperative agreement with the Agricultural Experiment Station of the University of Kentucky, Lexington, Kentucky. Federal effort amounts to 5.2 scientist man-years, of which 3 is by contract and 1.2 by cooperative agreement.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 1.0 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Biological and Physical Control. Many cigarette factories have converted to the use of flowing steam under vacuum for moisture conditioning their tobacco. Although field evaluation research was not completed when the basic research data were published, the industry was convinced of the merits of this method of moisture conditioning as a means of also obtaining insect control. As far as is known, the companies have had no problem with insect survival in the tobacco conditioned by this process. (MQ 1-37)

Third-instar larvae of the cigarette beetle were found to be more adversely affected by low temperatures than were those in the fourth instar. The larvae were exposed individually, each in $\frac{1}{2}$ gram of cornmeal rearing medium. All third-instar larvae were dead in 3 weeks of exposure to 40° or 45° F., and 70-80% relative humidity, 8 weeks at 50° and 55% r.h., and 12 weeks at 50° and 65% r.h. All fourth-instar larvae were dead in 3 weeks at 40°, 4 weeks at 45°, 20 weeks at 50° and 55% r.h., and 24 weeks at 50° and 65% r.h. (MQ 1-7(Rev.))

Hogsheads of flue-cured tobacco hands that had become heavily infested with the cigarette beetle in storage were exposed to constant temperatures of 40°, 45°, and 48° F. The humidity was kept high so the tobacco moisture content was between 12 and 15 percent. Temperatures were monitored at 4-, 12-, and 20-inch depths in the hogsheads and dropped to those of the test rooms in 3 to 4 weeks. Examinations were made each 4 weeks for living insects. Pupae were more susceptible to the cold than were third-instar

larvae. Adults and fourth-instar larvae were about equal in resistance to cold and both were highly tolerant. At 40°, 45°, and 48° F., exposures of 12, 20, and 32 weeks, respectively, were necessary to kill all cigarette beetles infesting the hogsheads. In other temperature observations it was found that the temperature of heavily infested hogsheads of tobacco in normal storage exceeded the warehouse temperature as much as 25° F., during the 6- to 8-week preconditioning period and were 8° to 12° F. higher than uninfested hogsheads in the spring. Hogsheads with only light or moderate infestations were within 2° of the warehouse temperature. (MQ 1-7(Rev.))

Environmental studies of the temperature and moisture in tobacco hogsheads as influenced by outside and warehouse temperatures and relative humidity have been conducted at Wilson, North Carolina, since December 1966. Conditions are monitored at different depths in the hogsheads and at different heights above the floor. Information from these observations, coupled with that from laboratory studies of temperature and humidity effects, will provide a better understanding of the relationships of infestation in warehouse storage. This in turn could lead to preventive or control measures based on the manipulation or control of environmental factors. (MQ 1-7(Rev.))

2. Improved Pesticidal Control. Eight compounds were evaluated against adult cigarette beetles. The residue of Geigy 12968 was still effective after aging 24 months. Compounds with residues effective 6 to 12 months were Bayer 37343 and Bayer 77488, Shell SD 8211, and Shell 8447. Ciba 2428 was the only compound with significant vapor toxicity. None was effective as a repellent or attractant. (MQ 1-35)

All 1960 crop tobacco has now been sold from a number of warehouses that have been under observation. That fumigated yearly with HCN at 3 lb./1,000 cu. ft. and treated biweekly with dichlorvos during the summer showed, at most, only trace amounts of insect damage at time of sale. Tobacco similarly protected with dichlorvos but with more frequent HCN fumigations at a 1-lb. rate suffered damage ranging from trace amounts to very heavy. Some hogsheads had to be removed from stock and sold at discount because of excessive insect damage. The higher fumigation rate is now being used in more warehouses, especially in the southern part of the flue-cured tobacco storage belt. A series of warehouses fumigated in the spring with the 3-lb. dosage of HCN and given daily dichlorvos applications remained insect-free the first summer of storage. Cigarette beetles began to appear by August of the second summer. Even with daily dichlorvos applications, a heavy fumigation may be required every second year to protect the tobacco. (Exploratory)

Observations on the efficacy of some commercial vacuum fumigations revealed that neither HCN nor acrylonitrile was giving consistent kill of fourth-instar cigarette beetle larvae at depths greater than 10 inches in tobacco hogsheads. HCN appeared to be slightly more effective than acrylonitrile at the dosages used. The penetration and kill were improved by:

- (1) fumigating at 1-1½ inches of absolute pressure instead of 4-10 inches,
 - (2) increasing the temperature in the fumigant volatilizer to 210-215° F. rather than 150°, and (3) reducing the flow rate of fumigant through the volatilizer.
- (Exploratory)

B. Quality maintenance

1. Effect of Postharvest Microflora on Tobacco Composition. A total of 2,382 isolates were obtained from 7 grades of aged burley tobacco. The microflora composition consisted of Aspergillus (31.5%), Penicillium (11.4%), yeast (20.5%), and bacterial species (29.1%). Aspergillus flvaus was the largest single species isolated (25.5%). Isolates of A. flavus were analyzed for their aflatoxin producing potential by chromatography and bioassay against Bacillus megaterium. Extracts of four isolates had Rf values similar to aflatoxin B₁ and G₁ standards and produced zones of inhibition when bioassayed against the aflatoxin sensitive bacteria.

(MQ 2-109)

2. Microflora on Flue-Cured Tobacco and Their Affect on Quality.

Isolations made from leaf tissue prior to and following flue-curing indicate that: (a) the predominant fungi isolated during 1966 were Alternaria, Aspergillus, Chaetomium, Cladosporium, Epicoccum, Nigrospora, Penicillium, Rhizopus, and Trichoderma; (b) Alternaria, Epicoccum, and Cladosporium represented 70% of all cultures obtained; (c) Alternaria and Cladosporium were reduced, but not eliminated, by flue-curing; (d) flue-curing did not reduce Epicoccum; and (e) Aspergillus ruber was isolated once from tobacco prior to flue-curing and almost 100 times following flue-curing, indicating that A. ruber apparently invades tobacco during or following flue-curing.

Nineteen genera of filamentous fungi (including 9 species of Aspergillus) were isolated from 51 samples of "moldy" tobacco received from a commercial tobacco company during the summer and fall of 1966. Aspergillus and Penicillium appeared to be the principal fungi responsible for deterioration, and tobacco moisture content appeared to determine which fungus species predominated as the main organism of deterioration.

A total of 1,372 cultures (1,206 fungi and 166 bacteria) from harvested, cured, or stored flue-cured type tobacco were tested for their ability to produce, in culture, materials toxic to warm blooded animals. An homogenate

of the micro-organisms and the culture medium was injected into mice interperitoneally. Tests made on 24 genera, including 8 species of Aspergillus, showed the following results: (a) 46% of the micro-organisms produced toxic metabolites; (b) Alternaria and Epicoccum produced the highest concentrations of toxic metabolites; and (c) 94% of the isolates of Epicoccum were toxic compared to only 51% of the isolates of Alternaria. (MQ 2-137(CA))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation

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Childs, Dana P. 1966. Effect on the tobacco moth of flowing steam vapor under vacuum. Tobacco Science, Vol. 10, pp. 113-115, In Tobacco 163(12): 30-32. (MQ 1-37)

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AREA 11 b

CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Problem. The rapid increase in production of field-grown narcissus, gladiolus, lilies, stocks, roses, and chrysanthemums into a multimillion dollar business in Florida, California, and other states has raised many problems in marketing. Methods of packaging, as related to cooling and market life, temperature requirements during transport and for limited storage periods, atmosphere modifications for storage and transit for both cut flowers and ornamentals, and the control of Botrytis rot are among the most urgent research needs.

USDA AND COOPERATIVE PROGRAM

The Division has a limited program in market quality research on cut flowers and ornamentals, amounting to approximately 2.0 scientist man-years. This research is conducted at the Fresno and Beltsville laboratories and at the Gulf Coast Experiment Station under a cooperative agreement with the Florida Agricultural Experiment Station. The California work is supported in part by the California Floral Traffic Conference and the California Florist Association.

No projects were terminated during the year.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 6.0 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in handling and packaging

1. Containers for Roses. Roses packed in vented polyethylene liners in an upright shipping container warmed to 5° to 8° F. above the ambient temperature. When deep-frozen gel ice was placed in the container above the liners, the temperature of the roses remained slightly below the ambient temperature during a 24 hour test period. The blooms were injured in the liners when temperatures were above 70° F., but with the cooling provided by gel-ice in the container, no injury occurred. Oxygen concentration decreased from 21% to less than 1% during 24 hours when roses were packed in the liner vented with 24 pin holes and was effective in maintaining the quality of the roses. Concentrations of CO₂ up to 20% caused no visible damage to the blooms or the

foliage. At temperatures below 60°, no gel-ice was necessary and the 21% O₂ was lowered to 6 to 7% without harmful effects. (MQ 2-105)

B. Quality maintenance in storage

1. Preservatives for Cut Flowers. The vase life of Dutch iris and lilacs at 70° to 75° F. was materially improved by using a chemical solution instead of water. The best preservative tested contained 3% sucrose, 400 ppm 8-hydroxyquinoline citrate and 300 ppm dimethylamino succinamic acid (Alar 90). Vase life of lilacs was increased from 2 days in water to 5 or more days in this preservative. Floret opening, floret size, and vase life of gladiolus were greatly improved by using a preservative rather than water during display at 70° F. The best preservative contained 5% sucrose, 200 ppm 8-hydroxyquinoline sulfate and 50 ppm silver acetate. Respiration rates of Friendship gladiolus at five temperatures varied from 12 to 16 mg/CO₂/kg./hr. at 33° to 84 to 142 at 70° F. (Exploratory)

2. Effect of Storage Techniques on Gladiolus Flowers. A storage period of 10 days for Florida or North Carolina gladiolus at either 33° or 40° F. after shipment was excessive as subsequent floret opening was poor. Glads stored dry 6 days in an atmosphere of 1% O₂ with 5% CO₂ at 33° or 40° F. opened slightly better after storage than control lots stored dry, in water or in air, but differences did not appear commercially important. The Friendship variety was severely injured (floret bleaching) by storage in modified atmosphere with 1% O₂ and 10% CO₂. Storage for 6 days at 33° or 40° F. in sealed 1.5-mil polyethylene bags or in a preservative solution was about as satisfactory as storage in an atmosphere of 1% O₂ with 5% CO₂. (MQ 2-105)

3. CA Storage of Lily Bulbs. Preliminary studies with three varieties of lily bulbs stored at 35°, 40°, and 45° F. for 4, 6, 8 and 10 weeks indicate some beneficial effects from reduced oxygen (3 to 10%) as compared with air. Most significant of the effects was the more rapid growth, after storage of bulbs held in the reduced-oxygen atmosphere. (MQ 2-105)

4. Ethylene Effects on Carnations. In experiments at Fresno, volatile emanations (1 ppm ethylene) from some lots of strawberries produced "sleepiness" in carnation blooms. Emanations from slightly deteriorated carnation blooms also caused sleepiness. When air from these chambers was filtered through brominated activated-charcoal before passing it over sound carnation blooms, sleepiness was prevented. Holding sound blooms in a chamber with a static atmosphere (0.2 ppm ethylene) also caused sleepiness, but when clean air was continuously passed through the holding chamber, no sleepiness occurred. Healthy carnation blooms produced about 9×10^{-6} ml of ethylene per hour, while "sleepy" blooms produced about 2×10^{-3} ml per hour per bloom. Cartons in which carnations were packed had 0.20 ppm ethylene if a few sleepy blooms were present, but only 0.075 ppm if all the blooms were sound. (MQ 2-105)

C. Postharvest disease control

1. Heat Treatments for Cut Flowers. Heating inoculated chrysanthemums for 20 minutes in moist air at 108° F. reduced Botrytis decay during 2 or 3 days at 68°. Thirty minutes at 108° or 20 minutes at 113° gave better decay control than 20 minutes at 108°, but caused injury to foliage and petals. Pom-poms (var. Hurricane and Starburst) were more resistant to heat injury than "mums", but the foliage in some cases yellowed prematurely following treatment.

Heating carnations to 108° F. for 20 or 30 minutes gave good decay control when the blooms were held at 36° F. for 4 weeks. Decay was further controlled when the blooms were held in 1/2% O₂ after the heat treatment, rather than in air. Treatments at 113° F. for 20 or 30 minutes caused injury to the foliage. (MQ 2-105)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance During Handling and Packaging

Waters, W. E. and H. F. Wilkins. 1967. Influence of intensity, duration, and date of light on growth and flowering of uncooled Easter lily. Amer. Soc. Hort. Sci. Proc. 90: 433-439. (MQ 2-105)

Quality Maintenance in Storage

Parsons, C. S., Sam Asen, and N. W. Stuart. 1967. Controlled-atmosphere storage of daffodil flowers. Amer. Soc. Hort. Sci. Proc. 90: 506-514. (MQ 2-105)

AREA 12

VEGETABLES - MARKET QUALITY

Problem. Most fresh vegetables are highly perishable. Research is needed on sources of inoculum and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening and aging. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Safe and effective transportation can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration and atmosphere modification and mechanical refrigeration with and without atmosphere modification has posed a series of new problems relating to effects on the commodities from use of substantial amounts of nitrogen or accumulation of carbon dioxide in the load compartments. Additional information is needed on objective indices for harvest maturity and quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of applied and basic research relating to quality measurement and protection of vegetables as they pass through the marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Md.; Fresno, Calif.; Orlando, Fla.; Belle Mead, N. J.; Chicago, Ill.; and Harlingen, Texas, and at the North Carolina Agricultural Experiment Station, Raleigh, N. C.

Projects terminated during this period included: Detection and description of freezing injury (MQ 2-29), Effects of high nitrogen on vegetables during simulated transit (MQ 2-71), Chilling injury on eggplant (MQ 2-86), Storage of asparagus crowns (MQ 2-89), Ozone on vegetables (MQ 2-102), and Relation of fresh product factors to processed quality in sweetpotatoes (MQ 3-50).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 19.9 scientist man-years is devoted to this area of research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Separation of Undercolor Tomatoes. Because "undercolor" tomatoes may affect the flavor of strained products but not the color, a prototype device was constructed to sort "undercolor" tomatoes from fruit used for juice manufacture. Tomatoes are sorted as acceptable or non-acceptable color by a device which measures the natural chemiluminescence of the fruit. The response is temperature dependent and electronic adjustment must be made for fruit temperature. The development of this instrument will make tomato inspection more objective and when used in-plant will overcome problems of trim-line color sorting. (Coop. Agreement with Campbell Soup Co.)

2. Maturity Separation of "Mature-Green" Tomatoes. In limited preliminary studies, mature-green tomatoes of HCL46 variety gave absorption peak of 585 nm on the Biospect. Similar green-color tomatoes which were immature did not show this peak and had not formed gel in the locules, which is a primary criterion for maturity. Mature-green tomatoes initially sorted with the Difference Meter (A.O.D. 570- 580 nm), ripened after 7 days at 70° F., were closely related (low to high values) to visual judgment of color change (green to red color). Tomatoes ripened at 70° F. under continuous 40 W cool white fluorescent light were redder both internally and externally than tomatoes ripened in subdued light. (Exploratory)

B. Quality maintenance in handling and packaging

1. Types and Effectiveness of Lettuce Wraps. Decay increased in all film-wrapped, inoculated lettuce when the ambient humidity was increased from 50 to 70 and 90 percent. Less moisture loss but more decay developed in lots wrapped in the non-perforated polystyrene and minutely perforated polyvinyl chloride A than in lots wrapped in vented cellophane or the more permeable films. Lettuce wrapped with non-shrunk polystyrene and polyvinyl chloride (b) had more marketable heads when held at low humidity than shrunk film-wrapped heads or the perforated film-wrapped lettuce. At higher humidities the perforated film-wrapped lots had less decay and more marketable heads generally than others. (MQ 2-80)

2. Origin-wrapped vs. Non-wrapped Lettuce. Quality differences between naked-packed and origin-wrapped California lettuce generally was slight in simulated shipping tests made in the laboratory and also in actual shipping tests to the east coast. Crushing and bruising were more prevalent in naked-packed lettuce than in origin-wrapped lettuce in the holding tests at the laboratory, but not in the actual shipping tests. Butt discoloration was slightly more severe in the naked-packed than in the origin-wrapped lettuce in lots examined at the laboratory and also in the lots examined on the east coast after 4 days at 50° F. (MQ 2-80)

C. Quality maintenance in storage

1. Intercellular Space in Sweetpotatoes. Intercellular space of four varieties of sweetpotatoes differed between varieties at harvest but in individual varieties it varied less than 1.5 ml. per 100 ml. of root volume at three harvest dates and three locations. Intercellular space in each variety at harvest differed little this season from the previous season. Large differences in weight losses and volume losses developed in roots of 10 commercial varieties of sweetpotatoes due to differences in development of intercellular space and pithiness. The largest amounts of intercellular space developed with rapid weight losses, small volume losses, low tissue specific gravities, and high respiration rates. An estimating equation capable of predicting intercellular space to within one ml. per 100 ml. of volume was developed. (MQ 2-128)

2. Sprout Inhibitors for Sweetpotatoes. A high rate of CIPC applied in fog form to stored sweetpotatoes, (30 ppm residue) reduced sprouting about 80 percent, and a low rate (10 ppm) reduced sprouting about 40 percent during about 6 months' storage. Roots removed after treatment contained less than 15 ppm CIPC residue in the most exposed location receiving the highest application.

In other storage tests 5 percent CIPC dust was applied to roots in the top layer of field boxes stacked 4 or 5 layers high on pallets as they were removed from the curing room and to the storage room. Dust was applied to provide the equivalent of 30 or 10 ppm CIPC residue to the roots. At desirable storage temperatures CIPC dust applied over the palletloads of sweetpotatoes as they were placed in storage reduced sprouting by 50 to 75 percent. Where storage temperature was not controlled as well, nontreated roots developed noticeable amounts of sprouts in the top of the stacks and treatment with dust at 10 ppm reduced sprouting very little except where dust concentration was greatest. (MQ 2-130)

3. CA Storage of Cauliflower. Undesirable darkening and softening in cooked cauliflower induced by prior holding in CO₂-enriched atmospheres is related to pH changes in the tissue. A rise in pH of 1.2 units, caused by high CO₂ in the atmosphere, was accompanied by significant increases in discoloration and softening. Aeration for 24 hours before cooking, and cooking the curds in acidified water eliminated the adverse effects of high CO₂.

The flavor of cooked cauliflower was affected adversely by prior storage for 4, 8, or 15 days at 41° F. in low O₂ atmospheres ($\frac{1}{4}$ to 2%). The off-flavors persisted when the heads were cooked after an additional 3 days in air at 50°. Visible injury resulted when the heads were stored 8 days at 41° in $\frac{1}{4}$ or $\frac{1}{2}$ % O₂. The flavor of heads stored in 5% O₂ was about equal to that of heads stored in air throughout. Shear resistance of the curd was not affected by low O₂ but the curd yellowed slightly during storage, especially in $\frac{1}{4}$ % O₂. Soft rot affected almost all heads held 8 or 16 days in $\frac{1}{2}$ or $\frac{1}{4}$ % O₂, but was negligible in samples from the other atmospheres. Cauliflower

held at 37° F. generally responded like that held at 41°. No off-flavors developed at 37° in 2% O₂. (MQ 2-123)

4. CA Storage of Radishes. Topped red radishes held at 37, 41, or 50° F. for 15 days in atmospheres with $\frac{1}{4}$, $\frac{1}{2}$, or 1% O₂ developed no top and root growth. At 50° surface mold grew on roots held in $\frac{1}{2}$ % O₂ and bacterial soft rot developed on those in $\frac{1}{4}$ or $\frac{1}{2}$ % O₂. Radishes held in 5% or 10% O₂ for 15 days did not differ appreciably from those held in air regardless of storage temperature. Pithiness, a sign of aging, was most severe at 50° F. and least severe at 37°, and its incidence was not affected by O₂ concentration. (MQ 2-123)

5. CA Storage of Broccoli. Yellowing of broccoli was slower in atmospheres containing $\frac{1}{4}$ or $\frac{1}{2}$ % O₂ than in air during 13 days at 41° or 50° F. At 37°, the effect of low O₂ on yellowing was evident only after 4 subsequent days in air at 50°. Samples held 13 days in $\frac{1}{4}$ % O₂ at 50° were as green as those held in air at 37°, while those held in air at 50° were completely yellow. The low O₂ concentrations did not induce injuries or off-flavors in broccoli at the temperatures tested. (MQ 2-123)

6. CA Storage of Texas Cantaloups. After 3 weeks at 40° F. cantaloups held in 1% oxygen were fairly bright, mostly acceptable and firm, and required several days at room temperature to soften. The effects of carbon dioxide in the atmospheres were not evident until the melons had been in 60° air for 3 days. Those that had been held previously in 1, 5, and 10% oxygen with either 5 or 10% carbon dioxide levels showed noticeably less mold growths than melons from similar oxygen levels but without carbon dioxide. (MQ 2-136)

7. CA Storage of Texas Honeydew Melons and Pineapples. Quality in honeydew melons was not benefited by storage in modified atmospheres. After 3 weeks at 45° F. melons held in 2.5, 5, and 10% oxygen were similar in appearance to those held in air. They were still comparable after an additional 6 days in 60° air. However, melons from reduced oxygen atmospheres with either 5 or 10% carbon dioxide were not acceptable because of *Alternaria* and bacterial spot decay. No benefits were obtained from modified atmospheres with the smooth Cayenne variety of pineapple in atmospheres similar to those used for honeydew melons. (MQ 2-136)

8. CA Storage of Asparagus. The quality of fresh asparagus was no better after one week in $\frac{1}{4}$, 1, or 3% oxygen atmospheres than in air at 32° or 50° F. An oxygen level of $\frac{1}{4}$ % injured the asparagus at both temperatures. One percent oxygen was injurious at 50°. After 1 week of storage, uninjured spears remained in fair condition for 5 days at 60° but almost all injured spears decayed. Only the $\frac{1}{4}$ % oxygen atmosphere reduced the respiration rate of asparagus at 32°. The over-all reduction for the 7-day storage period, as compared to air, amounted to 17%. At 50° respiration in atmospheres containing not more than 3% oxygen averaged about 30% less than in air. There was no difference in the tenderness of asparagus held one week in air and in controlled atmospheres containing 1% oxygen and zero, 5%, and 10% carbon dioxide. (MQ 2-136)

9. CA Storage of Celery. Celery held at 32° F. in 0% O₂ (100% N₂) had better color and condition than celery held in air after all storage periods and the subsequent deterioration at 68° F. in air was not hastened. At 41° F., exposure of 8 days or more resulted in damage. Oxygen concentrations between ½% and 21% (air) seemed to have very little effect at either temperature for all storage durations. Carbon dioxide, at concentrations from 5% to 20% resulted in somewhat better quality at time of removal from storage but tended to hasten deterioration after transfer to 68° F. The effect increased with CO₂ concentration. Celery stored in air at 32° F. maintained much better quality than that stored at 41° F. (MQ 2-136 Cooperative Agreement with the University of California)

D. Quality maintenance during transportation

1. Asparagus Simulated Air Shipment. Soft rot at the tips was nearly absent in asparagus after 2 days in air or in a CO₂ atmosphere gradually reduced from 22% by ½ every 7 or 19 hours. After 2 additional days in air, tip rot and soft rot at the butt end were significantly higher in spears held in air than in those held in CO₂. Tips that were open with buds visible or with actual feathering, had over twice the incidence of soft rot as tightly closed tips. (MQ 2-136)

2. Containerized Export Shipments. Irregular and slow cooling in the top-iced load of non-hydrocooled, prepackaged carrots in a mechanically refrigerated van, emphasized the need for precooling for a long haul to an overseas market. The degree of cooling obtainable within minutes by hydrocooling required 76 hours in one location in the carrot load. Vacuum cooling of the leafy vegetables in the mixed vegetable load plus 6,000 pounds of top ice reduced product temperatures to 42° to 43° F., which was maintained during most of the transit period by the van refrigeration unit. (MQ 2-139)

3. Load Patterns for Lettuce Shipment. Average load temperatures in mechanically refrigerated rail cars and trailers on flat cars (TOFC) were not appreciably affected by load pattern. But air circulation in both cars and trailers was improved by the bonded-block load pattern, as indicated by the more uniform temperatures in these loads than in the solid loads. Because of improved air circulation in the bonded-block loads, temperature variation was generally 2° or 3° F. less than in the solid loads. However, damage to the lettuce and container from crushing was greater in the bonded-block load than in the conventional solid load and less cartons could be loaded than in the solid load. (MQ 2-84)

4. Standing Test With Mechanically Refrigerated Rail Car and Van. Lettuce temperatures averaged 36° F. in a 50-foot mechanically refrigerated rail car and 37° in a piggyback trailer when the thermostats were set at 34° F. during a simulated transcontinental transit period. The difference between the warmest and coolest positions in the loads was 5° in the car and 6° in the trailer. Carbon dioxide in the atmosphere of the car had increased to 7.2 percent by the ninth day, but in the trailer the carbon dioxide level did not exceed 2.7 percent. Relative humidity was high (91 to 97 percent) in the car

and trailer. At unloading lettuce that had been maintained at 35° to 37° F. was rated "excellent" but that maintained at 38° or 39° was rated "good." (MQ 2-84)

E. Postharvest physiology

1. Ethylene Production by Lettuce. Studies were conducted to elucidate the relationship of temperature to ethylene production and russet spotting. Lettuce previously held for 4 days at 59° F. produced ethylene at a rate of 35×10^{-6} ml/kg-hr after 5 hours at 70° F; that held at 41° F. for 4 days produced 28×10^{-6} ml/kg-hr after 24 hours at 70°; and lettuce held at 32° F. for 5 days produced 50×10^{-6} ml/kg after 76 hours at 70°. (Exploratory)

2. Russet Spotting of Lettuce. Symptom-free lettuce from obviously mosaic infected areas of commercially planted fields had more than twice the number of heads affected by slight to severe russet spotting after 7 days' storage at 41° F. than lettuce from nearly virus-free areas of the same fields. After an additional 4 days at 50°, the proportion of moderate or severe russet spotting was similar. (Exploratory)

F. Postharvest disease control

1. Neck Rot in Onions. After 4 months in common storage, Ortho 5871 - 80 WP and Chemagro 50 WP gave good control of botrytis neck rot when dusted on freshly cut neck of onions. The controls developed 75% decay. Top killers were not effective for control of botrytis neck rot. Heat applied to the cut surfaces by flame or hot plate reduced neck rot decay in inoculated onions during 4 months in common storage. The reduction of neck rot with a commercial forced, heated air drier shows promise. (MQ 2-95)

2. Soft Rot in Bell Peppers. Hot water treatment of bell peppers, when used at 136° F. for 30 seconds provided good to excellent control of soft rot in commercial shipments. The effectiveness of the commercial hot water treatment was reduced by subsequent waxing of the pods. Considerable interest in hydro-heating peppers continues in Texas and additional commercial installations are planned. (MQ 2-133)

3. Enzyme Activity in Rhizopus-rotted Sweetpotatoes. No lipolytic and low proteolytic enzyme activity was detected in juice expressed from rhizopus-rotted sweetpotato. Procedures used to purify the enzymes give preparations of these unstable materials that had little or no activity. Nitrate salts are more effective than chloride, sulfate, and phosphate salts in inhibiting maceration of sweetpotato tissue by crude pectolytic enzyme from rhizopus-rotted sweetpotato. Potassium nitrite and potassium azide were as effective as potassium nitrate at 0.5 M concentration and pH 5.5. Under the same conditions, hydroxylamine had no effect. (MQ 2-129)

4. Heat Treatment of Texas Cantaloups. Cantaloups from 4 packing sheds in the Rio Grande Valley which used hot water treatments were evaluated after

6 days at 60° F. All untreated melons were unsalable at the end of the holding period, while those dipped in water at 140° for 20 to 30 seconds showed only slight surface mold at the stem scar. Controlled tests in the laboratory and commercial equipment gave similar results. The addition of 0.15% SOPP to the hot water did not increase its effectiveness. Chlorine solutions were not effective. (MQ 2-134)

5. Effects of Chlorine on a Vegetable Decay Organism. The detergent surfactants, alkyl aryl sulfonate (Santomerse), coco trimethyl ammonium chloride (Aliquot 21), and sodium tetradecyl sulfate (Tergitol Anionic 4) were effective in increasing fungicidal activity of calcium hypochlorite in vitro against Alternaria tenuis spores. Only Santomerse has been approved for post-harvest application. Mature green tomatoes washed in field equipment containing sodium hypochlorite and Santomerse had less bacterial necrosis and soft rot than tomatoes washed without disinfectants. Sodium hypochlorite alone was ineffective in reducing tomato bacterial decay. The hypochlorite-Santomerse mixture was also effective in reducing soft rot of carrots. (MQ 2-116)

6. Market Diseases of Puerto Rican Vegetables. The following commodities have been investigated for market disorders as they arrive on the Chicago market: apio (6), boniato (2), calabaza (6), ñame (17), yautia (9), and yuca (4). The figure in parentheses indicates the number of different organisms isolated from the diseased areas of the commodity. The predominant organisms are Alternaria, Cladosporium, Fusarium, Penicillia, Rhizopus, and bacteria. Re-inoculation studies indicate most of the organisms repeatedly isolated from decayed areas are pathogenic. (MQ 2-131)

7. Market Losses in Lettuce. In the New York City market average loss in head lettuce at wholesale was about 3%; retail losses averaged about 6% and wastage at the consumer level was almost 9%. About 2/3 of the total loss was due to decay with the remainder caused by bruising and rib breakage. Total loss was about the same in the Chicago market but less of the loss occurred at retail and more at the consumer level. (MQ 2-132)

8. Identification of Market Diseases. New symptoms of black leaf speck were seen on cabbages received from Florida. In addition to the typical black specking of the leaves, many major and minor veins throughout the head had a grayish-blue water-soaked appearance. In some instances the discoloration was local, in others it extended over a considerable portion of the vein. This aspect of black leaf speck is related to high copper content of soils in the Sanford area of Florida. Symptoms usually did not appear until cabbages are held at low temperatures.

Geotrichum candidum, the fungus causing sour rot, was isolated from practically every sample (15) of carrots observed, regardless of where they have been grown or their condition. (MQ 2-64)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance During Handling and Packaging

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Hruschka, H. W. 1966. Storage and shelf life of packaged rhubarb. U. S. Dept. Agr., Marketing Research Report No. 771. (MQ 2-61)

Stewart, J. K., M. J. Ceponis, and C. M. Harris. 1967. Market quality of film-wrapped and naked-packed head lettuce. U. S. Dept. Agr. ARS 51-11. (MQ 2-84)

Quality Maintenance During Storage

Hoover, M. W. and L. J. Kushman. 1966. Influence of raw product storage treatments on the quality of sweet potato flakes. Amer. Soc. Hort. Sci. Proc. 88:501-506. (MQ 2-73)

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Wright, F. S., W. E. Splinter and L. J. Kushman. 1967. The influence of variety, time from harvest, and storage conditions on the mechanical behavior of the sweet potato. (Abstr.) Southern Agr. Workers Proc. 64:47-48. (MQ 2-128)

Quality Maintenance During Transportation

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Postharvest Disease Control

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- McColloch, L. P. 1966. Chilling injury of eggplant fruits. USDA, Marketing Research Report 749. (MQ 2-86)
- McColloch, L. P. and W. R. Wright. 1966. Botrytis rot of bell peppers. USDA, Marketing Research Report 754. (MQ 2-52)
- Segall, R. H. 1967. Bacterial soft rot, bacterial necrosis, and alternaria rot of tomatoes as influenced by field washing and postharvest chilling. Plant Disease Reporter 51:151-152. (MQ 2-116)
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- Spalding, D. H. 1966. Toxic action of Rhizopus stolonifer in sweetpotato tissue. (Abstr.) Phytopathology 56:902. (MQ 2-129)

AREA 13

INSECT CONTROL IN MARKETING CHANNELS - CROSS COMMODITY

Problem. There are over 100 kinds of insects, 15 or 20 of which are extremely abundant and widespread throughout the world, that commonly attack agricultural commodities after harvest, in storage or in shipping, during processing or milling, and in wholesale and retail marketing distribution. Still other kinds cause occasional or incidental troubles. The stored-product insects cause an annual loss in the United States of up to one billion dollars through feeding damage or by contamination that reduces quality and value of products. It is proper that attention should be given to increased production as a means of meeting the acute food shortage predicted for the world within a few years. It is wasteful and unwise to permit insects to destroy or defile sizeable amounts of what has already been produced. The food we produce should be for hungry people, not to feed the insects. This emphasizes the need for applied research to develop more effective, economical preventive and control measures that are safe and do not leave objectionable pesticide residues when used against stored-product insects. There is also a need for extensive basic research to provide a sound foundation for conducting effective applied studies, and to provide leads for developing completely new approaches to prevention and control.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program headquartered at Savannah, Georgia, in basic and applied research involving entomology, biochemistry, analytical chemistry, biophysics, and physics. It is directed toward the solution of problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with a large number of research, regulatory, and action agencies in USDA and other departments of the Federal government; several universities and State Agricultural Experiment Stations; and a large number of trade associations or individual firms in the chemical, paper, synthetic film, packaging, food processing, and milling industries. The Atomic Energy Commission transferred funds to assist the program in irradiation research. Commodities for experimental purposes were made available by the Commodity Credit Corporation through the Agricultural Conservation and Stabilization Service.

There was an extensive extramural program supported by contract, grant, cooperative agreement, and P.L. 480 funds, distributed in several phases of research as follows:

A. Biological and physical control

A 2-year cooperative agreement with the University of Georgia continues until June 1968 for research on the effects of light on dermestids and mites that attack stored products.

A 2-year cooperative agreement with the University of Florida continues until June 1968 for studies on the production and reception of sound by stored-product insects.

A grant to the University of Georgia was for a 2-year study through June 1967 on the effects of various frequencies and intensities of sound waves on the behavior and physiology of the Indian-meal moth.

A 1-year cooperative agreement with the University of Georgia continues until June 1968 for studies on the perception and behavioral effects of sound in the Indian-meal moth.

A grant to the University of Oklahoma is for a 3-year study through June 1970 on the morphology of sound receptors in stored-product insects.

A grant to the University of Georgia was for a 2-year study through June 1967 on the effects of gamma radiation on the physiology and reproductive potential of mites that attack stored products.

A 2-year cooperative agreement with the University of Georgia continues until June 1969 for further studies to determine the effects of gamma radiation on the reproduction physiology of the grain mite.

A grant to Shaw University is for a 2½-year study through September 1968 on host specificity in certain stored-product insects.

A grant to the University of Georgia was for a 2-year study through June 1967 to investigate the existence and origin of a sex attractant pheromone in the Indian-meal moth, and to evaluate the physical and chemical properties of the pheromone.

A 3-year cooperative agreement with the University of Georgia continues until June 1970 for further studies on and the determination of the sex attractant in the Indian-meal moth.

A grant to the University of California at Berkeley is for a 3-year study through June 1968 on the host finding behavior and parasitization performance by a hymenopterous parasite of a moth species that attacks stored products.

A 2-year cooperative agreement with Clemson University continues until June 1969 for a study to determine the role of parasites and predators in eliminating populations of the Indian-meal moth.

A grant to the Hebrew University, Jerusalem, Israel, is for a 3-year study on the potential use of antimetabolites for the control of certain stored-product insects. It continues until August 1968 and involves P.L. 480 funds with a \$65,457 equivalent in Israeli pounds.

B. Biology, ecology, physiology, and nutrition

A 2½-year cooperative agreement with the University of Florida continues until October 1968 for a study on the nutritional requirements of the almond moth.

A 2-year cooperative agreement with the University of Illinois continues until June 1968 for a study on the utilization of food by certain stored-product insects.

A grant to Clemson University was for a 2-year study through June 1967 on the bionomics of the Indian-meal moth.

A grant to the Iowa State University is for a 3-year study through June 1968 on low-temperature adaptation and chill coma in stored-product insects.

A grant to the University of California at Riverside is for a 3-year study through June 1969 on the comparative life histories and bionomics of Trogoderma species.

A 3-year cooperative agreement with Clemson University continues through June 1970 for research on the endocrinology of reproduction in the rice and granary weevils.

A 2-year cooperative agreement with Cornell University continues through June 1969 for research on the role of quinones in regulating populations of Tribolium confusum in foods and feeds.

C. Mode of insecticide action and development of resistance

A grant to the Iowa State University is for a 3-year study through June 1968 on changes in activities of oxidative detoxication enzymes as related to age and stage of stored-product insects.

D. Improved pesticidal control

A contract with the Vacudyne Corporation to be completed in Fiscal Year 1968 is for investigations to design, construct, install, and test an experimental fumigation chamber with controlled temperature, relative humidity, vacuum, and pressure features unlike any ever previously built.

A grant to the National Botanic Gardens, Lucknow, India, is for a 5-year study on certain plant (inclusive of neem) extracts and isolates having pesticidal properties. It is cosponsored with the Entomology Research Division, continues until December 1971, and involves P.L. 480 funds with a \$63,506 equivalent in Indian rupees.

E. Insect-resistant packaging

A 2½-year contract with the Battelle Memorial Institute continues through December 1967 for research to develop practical formulations and methods of application to paper that will prevent migration of insecticides or repellents from packaging components to products inside the containers.

A 2½-year contract with the Midwest Research Institute continues through December 1968 for the development of effective insect repellents for protecting stored agricultural commodities and packaged products.

F. Simplified pesticide residue analytical methods

A 2-year contract with the F&M Division of the Hewlett-Packard Company continues through June 1968 for research to develop a portable gas chromatograph instrument and mobile laboratory for rapid on-site analysis of pesticide residues in plant and animal products.

A 1½-year contract with the Stanford Research Institute continues through December 1967 for research to develop simple, rapid methods of extraction and cleanup for pesticide residue analysis.

A 1¾-year contract with the General Foods Corporation continues through March 1968 for research on the development of antibody reactions specific for pesticides and their adaptation to rapid and sensitive residue analysis.

The Federal effort on the cross-commodity entomological research totaled 24.5 scientist man-years, of which 4.4 was in contracts, 3.9 in grants, and 0.9 in cooperative agreements. The manpower was distributed as follows: biological and physical control, 6.9 plus 1.6 in grants and 0.3 in cooperative agreements; biology, ecology, physiology and nutrition, 3.2 plus 1.8 in grants and 0.6 in cooperative agreements; mode of insecticide action and development of resistance, 1.1 plus 0.5 in a grant; improved pesticidal control, 1.8 plus 0.9 in a contract; insect-resistant packaging, 1.2 plus 0.9 in grants; simplified residue analysis, 2.6 in contracts; and fate and effect of residues, 1.1.

Line Project MQ 1-50(C) on the development of rapid test methods and a portable field kit for the qualitative detection of the major classes of pesticides in the major food commodities was discontinued after the successful completion of the contract.

P.L. 480 project E21-AMS-4, a study in Poland of the insect pathogen, Bacillus thuringiensis, as a possible control measure against certain moths that attack stored products was completed in May 1967.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientist man-years in this area of research are included in the 12 commodity areas.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Biological and physical control

1. Light. Neither larvae nor adults of the almond moth showed any significant response to several wavelengths of light tested. Adults of a white-eyed strain did not respond either but a considerable number of larvae gave a positive response to green light at 5100 Å. Traps equipped with ultraviolet light sources caught 22% more insects in a peanut warehouse than did traps with green-electroluminescent lights. About two-thirds of the insects were noctuid moths, various flies, and other nonstored-product insects. The green light traps caught about twice as many almond moths as did the ultraviolet light traps. However, in a 5,000-cubic-foot laboratory room more Indian-meal moths and almond moths were attracted to traps with ultraviolet light than to those with green light. (MQ 1-12)

Adult black carpet beetles gave a maximum negative response to light at the age of 1 to 3 days. After 5 days of age the negative response decreased sharply and at 8 days of age there was a slight positive

response. With further increase in age the beetles were rather indifferent in response to light. There was little difference in response as a result of sex, whether mated or not, or of various rearing conditions.

(Cooperative Agreement, University of Georgia)

2. Production of Sound by Insects. No sounds of biological importance were detected to be produced by larvae, pupae, or adults of the Indian-meal moth, rice weevil, cigarette beetle, saw-toothed grain beetle, red flour beetle, black carpet beetle, and Trogoderma glabrum; larvae or adults of the cadelle; or adults of the Angoumois grain moth, webbing clothes moth, and lesser grain borer. The studies on adults included both sexes, mated and unmated. Tests were made under various environmental conditions such as the presence or absence of food; varying light intensities; in competition with other species, including parasites; and under such stress conditions as pressure, shock, heat, and strong irritants such as ammonia or formaldehyde. Wing flutter sounds were detected and recorded from adults of the Indian-meal moth, Angoumois grain moth, webbing clothes moth, cigarette beetle, and black carpet beetle. None of these sounds elicited any visible response when played back to insects. All other sounds detected appeared to be caused by the insects moving about or feeding. These movement and chewing sounds were investigated as possible means for detecting an insect infestation. Rice weevil larvae feeding inside kernels of wheat and the movement of red flour beetles in flour were easily detected inside an anechoic chamber, but not in competition with general background noise in the laboratory. (MQ 1-12)

No sounds at the 1 kHz level or in the 15 to 60 kHz range, other than those from normal insect movement, were detected among colonies of the confused flour beetle or the merchant grain beetle. No stress sounds resulting from pinching, squeezing, or scratching, and no mating sounds could be detected from the confused flour beetle.

(Cooperative Agreement, University of Florida)

3. Effect of Sound on Insects. Indian-meal moths were confined in quart Mason jars or plastic dishes with culture media and exposed to a variety of frequencies, intensities, and types of sound. No significant difference occurred in the number of F₁ generation individuals produced between those exposed to these sounds and those not so exposed. Observations were made on the behavior of adults of a number of stored-product insect species exposed to random noise and various frequencies and intensities of sound in an attempt to determine whether the insects could hear or detect sounds. Some increased activity and movements of legs and antennae of the black carpet beetle were occasionally noted, but the response was not consistent. There was no evidence to prove the insects were actually "hearing." (MQ 1-12)

Exposure of adult Indian-meal moths to sounds of 200, 2,000, 10,000, or 20,000 Hz had no consistent effect on the number of matings, number of eggs retained by the female, or sex ratio in the F_1 generation. There was, however, an average reduction of 22.7% (range 8.5 to 39.5%) in the number of F_1 produced from moths exposed to the 200-Hz sound. Moths 1 day old exposed for 4 subsequent days to sound of 10,000 Hz laid 41% fewer eggs than did unexposed adults. When young pupae were exposed to sound at 2,000 Hz for 5 days, and the resulting moths were reared in jars, there was a 27% reduction in progeny from treated insects. None of the frequencies influenced the ability of the moths to select an oviposition site in the food media and they did not select locations with either high or low intensity sound. More moths were caught in traps placed in association with a speaker transmitting sound at 10,000 Hz than in traps without sound. It remains to be determined whether the moth's olfactory sense or flight orientation, or both, are affected by the sound. No effect on cholinesterase activity was detected in moths exposed to sound at 10,000 Hz during the night before the assay was conducted. (MQ 1-47(Gr))

4. Biophysical Research. Electron microscope studies of the antenna of the Indian-meal moth revealed details of structure and organization of several sensory receptors previously undescribed. Light and electron microscope studies of the antenna of the saw-toothed grain beetle larva revealed a complex receptor structure on the terminal segment. This may be a hygroreceptor. Preliminary studies on adults of the black carpet beetle indicate that a large ocellus on the head may have an important relationship to phototropic behavior. Preliminary investigations of the sex-attractant gland of the Indian-meal moth indicate it is similar to that organ studied in other species. (Exploratory)

5. Gamma Irradiation. Wheat was treated with malathion at the rate recommended for application as a protectant. Portions were treated with 25 and 100 krads, within the range of estimated practical radiation levels. Samples were subjected to bioassay with red flour beetles and to chemical analysis at intervals subsequent to irradiation. Biological effectiveness of the malathion was not impaired and the degradation of the insecticide proceeded normally. Several dosages of malathion and synergized pyrethrum were applied to strips of brown kraft paper and irradiated at 25, 50, 100, 500, 1,000, and 4,300 krads. The last two are massive radiation levels and should reveal whether there would be any adverse effect on these insecticides. There was none revealed by bioassay tests with red flour beetles at intervals after radiation was applied. (MQ 1-12)

Eggs were obtained from the mite Acarus siro after irradiation as eggs, larvae, protonymphs, and tritonymphs at 50, 40, 35, and 30 krads, respectively. This is a reversal of the results with insects where resistance to radiation increases rather than decreases through successive stages of development. When small colonies of this mite were irradiated, egg production continued at all dosages through 50 krads. There was an increase in egg production at 10 and 15 krads, then a distinct decrease above that dosage in comparison with untreated controls. Egg hatch decreased with each increase in dose for about the first 4 weeks after treatment. Colonies irradiated at 10 and 15 krads could not be distinguished from controls on the basis of age classes of the various stages after the first 6 weeks. No new young were observed in any colony during the first 6 weeks after irradiation with 20 krads or more. Larvae were again found in colonies 6 weeks after irradiation at 50 krads, the highest level for which tests are completed. Colony recovery was so rapid that the age class distribution was again normal by the end of the 9th week for doses as high as 30 krads. Such recoveries are considered at this time to result from incomplete sterilization of the mites at doses through 50 krads. It is possible that the irradiation causes temporary sterility by damaging the later stages of spermatogenesis. This theory remains to be investigated. (MQ 1-45(Gr))

6. Host Specificity in Cereal Grains and Legumes. Water extracts of cereal grains were shown to contain a material or materials attractive to the rice weevil. Water extracts of the blackeye pea contain substances attractive to the cowpea weevil and repellent to the rice weevil. There are indications that water extracts of cereal grains or legumes may contain oviposition attractants. (MQ 1-63(Gr))

7. Sex Attractant. Bioassays with extracts of different ages of larvae and pupae of the Indian-meal moth showed there was production of a sex attractant in trace amounts by female pupae 1 day before emerging as adults. There was high production by adult females from 1 hour to 5 days after emergence. Males that survived gamma irradiation were as responsive as untreated males to the attractant of the female. Females irradiated with 50 krads produced a pheromone still attractive to males. Wind tunnel tests with the attractant showed that physical contact of the attractant molecules with receptors on the male is necessary to evoke a behavioral response. Males responded only when the attractant was placed upwind, but as far as 15 feet. (MQ 1-46(Gr))

8. Parasite Behavior. In a study of host finding and parasitization of larvae of the Mediterranean flour moth by parasitic wasp, Exidechthis canescens, the size of the test environment was apparently not large

enough for basic differences to show up under different host dispersion patterns. Differences due to host density are developing, however. Percentage of parasitization was highest at 30-density host levels, less at 100-density levels, and least at 200-density levels. At the high level, a 90-egg mean may indicate this is about the maximum number of eggs the female lays under these conditions. (MQ 1-42(Gr))

9. Biological Control. Further information was obtained on the comparative effectiveness against the Mediterranean flour moth of 9 preparations containing Bacillus thuringiensis, plus 3 new ones added to the testing program this year. Analysis and summary of the results will be in the final report of the project. Part of the program has been coordinated with that of the Working Group for Standardization of Biopreparations since the meeting of the International Colloquium for Biological Control in Wageningen, Netherlands, in September 1966. (E21-AMS-4)

10. Physiological Control. An interesting finding in studies with Dermestes maculatus in Israel is that the most effective antimetabolites tested thus far are antagonists of biotin and folic acid, which are required by the insect in extremely smaller amounts than the remaining B-vitamins. Larvae and adults were not adversely affected by excessive doses of B-vitamins, except that overdoses of biotin caused sterility in adult females. Some of the antimetabolites greatly extended the period of insect development. Since reducing the number of annual generations could have practical ecological significance, further attention will be given to effects of substances on fertility and fecundity. Juvenile hormonelike compounds, precursors and analogues of farnesol, also caused remarkable prolongation of the larval period, considerable larval mortality, and greatly delayed pupation. In tests with a series of fatty acids and related compounds some stimulated larval growth, some were feeding repellants, and some suppressed larval growth or completely prevented metamorphosis. There is evidence of gradual adaptation of starved larvae to dietary antimetabolites, a point requiring further study. (A10-MQ-4)

B. Biology, ecology, physiology, and nutrition

1. Mitochondrial Metabolism in the Indian-Meal Moth. A technique for isolating mitochondria from larvae of the Indian-meal moth and a reliable procedure for studying their oxidative activities have been developed. The oxidation rates and respiratory control indices for a variety of substances are being determined for mitochondria isolated from larvae at different stages of development. Data thus far indicate a general decline in mitochondrial activity in the late stages of larval development. This is accompanied by a decrease in mitochondrial nitrogen per unit weight of tissue. (MQ 1-53)

2. Carbon Dioxide Poisoning. Preliminary work indicates that an insect's susceptibility to carbon dioxide poisoning may be in relation to its rate of respiration. Indian-meal moth larvae consume oxygen at a much greater rate than do larvae of Trogoderma glabrum and are much more susceptible to carbon dioxide poisoning. (MQ 1-53)

3. Photoperiod Studies With the Indian-Meal Moth. Darkness or very low light intensity enhance mating activity of Indian-meal moths. In darkness, over 90% of females were mated within 24 hours after emergence while under constant light only 50% were mated in the same time. Preliminary observations also show that darkness enhances oviposition and that constant light delays oviposition at least for the first 24 hours after emergence. Under alternating light and dark cycles all oviposition was during the dark period. (MQ 1-56)

4. Humidity and Insect Behavior. The saw-toothed grain beetle has demonstrated its ability to perceive and respond to different levels of relative humidity. Adults that had been reared at 30° C. and 80% RH were offered a choice between 92% and 10% RH and showed a preference for the drier condition. Adults that were desiccated and starved for 24 hours showed much less preference for the dry condition and such treatment for 48 hours caused a complete reversal of behavior. Similar reactions to humidity have been demonstrated in other stored-product insects that normally inhabit relatively dry environments and are resistant to desiccation. (Exploratory)

5. Insect Rearing. Additional facilities were provided for insect rearing to meet the increased demands for test insects in the expanding research program. Also, mass rearing of the Indian-meal moth is yielding 150,000 adults per week for use in extraction of the sex pheromone in cooperative research at the University of Georgia. (Unclassified)

6. Bionomics of the Indian-Meal Moth. Late-instar larvae of the Indian-meal moth gave a negative phototactic response to white light. A parasitic wasp, Bracon labetor, a predatory mite, Melichares tarsalis, and two symbionts were discovered in the colonies of insects, and may be considered later in relation to their influence on populations. (MQ 1-44(Gr))

7. Low Temperature Adaptation in Stored-Product Insects. Striking effects of thermal acclimation at high, medium, and low temperatures on the dispersion of insects in stored products were demonstrated in tests with adults of the cadelle, confused flour beetle, and Trogoderma inclusum. The effects have also been studied with several larval stages of the cadelle and the confused flour beetle. Curves relating time and the temperature that induces chill coma have been developed for adults of the confused flour beetle, rice weevil, and Trogoderma inclusum when acclimated at 20°, 25°, and 30° C. (MQ 1-48(Gr))

8. Bionomics of Trogoderma. Extensive collections of Trogoderma from a variety of locations in California are yielding information on species distribution and relative abundance under different environmental and climatic conditions. Life history studies in the laboratory at different temperatures and humidities are in progress with 7 species of Trogoderma. Tests on the influence of temperature and humidity on viability and duration of the egg stage have been completed for 4 species. Matings of T. parabile are being made from parent stock collected in different areas and stock from the same area but in different years, to study the genetic plasticity of the species. A total of 2,930 specimens from 409 samples collected at 157 locations has been examined for the presence of disease organisms. A species of Mattesia was present in 92% of the 409 samples, a gregarine in 25%, and Adelina sp. in 4%. (MQ 1-54(Gr))

9. Blind Red Flour Beetles. A laboratory strain of red flour beetles was indicated to be blind by retinal probe methods. Crosses of blind and normal beetles indicated the blindness is inherited as a sex-linked recessive trait. A clue as to how the blind strain may have been selectively developed in laboratory cultures was found in preliminary tests with a genetically-marked black strain of the blind beetles. The blind beetles climbed onto cards placed in the culture medium in greater percentages than did a nonblind strain. The card method of removing flour beetles from the rearing medium has been used at the Savannah laboratory for several years. (MQ 1-23)

C. Mode of insecticide action and development of resistance

1. Oxidative Detoxication Enzymes. Larvae and adults of Trogoderma parabile have equal capacity to epoxidize heptachlor. The loss of heptachlor from larvae and adults of the Indian-meal moth, cadelle, and T. parabile is much greater than can be accounted for by heptachlor epoxide production. The rapidly decreasing amounts of heptachlor that can be recovered from treated insects can be accounted for by loss from their bodies to the air and the walls of the holding vials. High mortality of T. parabile larvae and adults occurred when they were treated with Nanograde hexane under carbon dioxide anesthesia. This does not occur with acetone, which is now used as the solvent for topical application of heptachlor. (MQ 1-43(Gr))

2. Resistance to Malathion. Five strains of the almond moth collected from peanut warehouses in Georgia and Florida showed 8- to 13-fold resistance to malathion over the normal laboratory strain. This is about a 3-fold general increase in resistance over strains collected during the 1965-66 storage season. Malathion had been used in some of the warehouses for 7 storage seasons. Bay 77488, a new phosphorus compound insecticide

with very low mammalian toxicity, was highly effective against the normal and malathion-resistant strains of almond moth larvae. Bay 78182, a closely related compound, was more effective than malathion against normal and malathion-resistant strains of red flour beetle adults, but there was considerable cross resistance from malathion. Two new synergists for carbaryl greatly increased its effectiveness against normal red flour beetles and tests are under way with malathion-resistant beetles.

(MQ 1-23)

D. Improved pesticidal control

1. Preliminary Evaluation. Two new compounds were highly synergistic with carbaryl in preliminary tests against confused flour beetle adults and black carpet beetle larvae. Since carbaryl and other carbamates are not generally very effective against these insects, the finding of synergists may open the way for potential development of a new group of safe insecticides for use against stored-product insects. Preliminary evaluation of 65 new compounds against 2 representative stored-product insects revealed 34 promising enough for further testing. In the next elimination 21 were selected for formulation and developmental studies. Dosage-mortality curves were established for Tropital as a new pyrethrins synergist but in general piperonyl butoxide was more effective as a synergist in these direct-contact tests. A comparison of malathion toxicity to red flour beetle adults immobilized by cold and those anesthetized with carbon dioxide showed a trend toward higher mortality in the latter but it was not significant at the 5% level. Tests were completed to establish the LD values for malathion, Dursban, diazinon, and DDT against larvae and adult males and females of the almond moth.

(MQ 1-23)

Of 29 new compounds evaluated, Stauffer R-11898 and R-8963 and Ciba 11044 were more effective than methyl bromide as space fumigants against confused flour beetle and cigarette beetle adults and black carpet beetle larvae. None of the compounds was effective in penetrating grain as a fumigant. Tetrachlorocyclopropene, previously found more effective than methyl bromide in preliminary space and grain fumigations, was indicated to be more effective against confused flour beetles at 60° F. than at 80°. Such interesting and unusual performance needs further verification. Ethide (1,1-dichloro-1-nitroethane), previously found effective as a space fumigant, was shown to be more effective than methyl bromide as a fumigant for wheat at 80° F. As with most other fumigants, the effectiveness decreased at lower temperatures.

(MQ 1-28)

2. Practical Control Problems. Lindane-treated paper board and dichlorvos-impregnated resin strips were found to be potential ways of protecting museum specimens in cases supplied by the Smithsonian Institute for test purposes. Dichlorvos gave better results than lindane under the test conditions and with the application rates used. Daily applications of dichlorvos aerosol dispensed by an automatic system at a cannery in a warehouse where empty cans are stored prior to filling have given protection for 2 months against insects getting into the empty cans. After 2 months of treatment, residues of 7.5 micrograms per can were found inside unbroken containers of cans. Performance and residues will be determined at the end of 3 months of testing. Potential use of this method will be dependent upon the nature of tolerances established for dichlorvos in foods as a result of a petition now pending with the Food and Drug Administration. (MQ 1-25)

3. Control of Fabric Insects. Through the Armed Forces Pest Control Board the Air Force requested this Department to assist in solving a problem of carpet beetle damage to rubberized animal hair used to protect electronic instruments in packing cases against vibration and impact shock during shipping and handling. The insulating value was lost when insects consumed the hair. In cooperation with a producer of the rubberized hair a procedure was developed to apply DDT as a protective treatment during the manufacturing process. Bioassay tests showed it was effective. The results were used in preparing a proposed Federal Specification PPP-C-1120. A spray booth was designed for the Air Force to use for applying DDT spray to the untreated cushioning material now on hand. The additional research cost only \$2,200 above that previously conducted. The Air Force estimates these research results will save them \$300,000 a year for 3 years in preventing loss of cushioning material and in avoiding repacking and extra handling. This is only a small fraction of the saving because no estimate has yet been made of the cost of damage to instruments, repairs, rechecking, and recalibration. (MQ 1-26)

Treating rayon thread with pyrethrins plus piperonyl butoxide protected it completely against feeding damage by cigarette beetle larvae and produced high mortality in the test insects. Dusting untreated thread with degermed cornmeal or wheat flour made the fibers more attractive to the insects and increased the amount of damage. The cigarette beetle causes serious damage to rayon bags used for animal feed and similar products. (MQ 1-26)

4. Experimental Fumigation Chamber. Construction was delayed while some refinements not originally anticipated were incorporated into the system. Final shop testing was completed and the chamber shipped and installed at

the Savannah, Georgia, laboratory. Performance tests revealed conditions that resulted in making several further improvements in the chamber. To achieve the specified precision of control required in operation, an additional modification was necessary and the work is in progress.

(MQ 1-41(C))

5. Juvenile Hormone-Mimicking Compound. Farnesyl methyl ether was tested in topical applications against larvae and pupae of 6 species of stored-product insects and gave less than 50% mortality in concentrations up to 5,000 p.p.m. There was high mortality when larvae of the cigarette beetle and the confused flour beetle were placed on diets containing 40 p.p.m. of the compound, but 20 p.p.m. was much less effective.

(MQ 1-23)

E. Insect-resistant packaging

1. Evaluation of Repellents. Preliminary evaluation of 63 compounds revealed 17 more repellent than synergized pyrethrins to red flour beetle adults. Eight were rated in Class V, giving 80 to 100% repellency. All but 2 of the top 17 compounds came from the Midwest Research Institute synthesis contract under MQ 1-40(C).

(MQ 1-20)

2. Synthesis of Repellents. Fifty-one compounds were prepared and submitted to the Savannah laboratory for preliminary biological evaluation. A high percentage was more effective than the synergized pyrethrins standard, showing the merits of a guided and selective synthesis program. Preliminary mammalian toxicity tests were conducted with 22 of the more promising compounds.

(MQ 1-40(C))

3. Residue Barriers. Several series of barrier systems were prepared for testing. These included saran, polyvinyl chloride, polyvinyl acetate, polyvinyl alcohol, polycarbonate, and acrylonitrile applied from solvent and emulsion systems to undercoats of styrene-butadiene or polyethylene.

(MQ 1-39(C))

Biological evaluations have been made on 82 barrier systems and repellent formulations prepared under MQ 1-39(C). The single-ply concept of barrier and repellent on the same sheet of packaging component appears to be impractical. There are indications that applying barrier coatings over polyethylene reduced their effectiveness. Saran or polyvinyl alcohol coatings over an undercoat of styrene-butadiene were some of the more effective barriers to residue migration.

(MQ 1-1(Rev.))

4. Physical Resistance to Insect Penetration and Invasion. A polypropylene overwrap on shell cartons gave excellent protection against infestation of cartons of raisins and cake mix. Two major food firms have

begun using polypropylene-type packaging films on the basis of these findings. Initial results indicate that polypropylene packets for spaghetti and pizza mixes are much more resistant to insect infestation than are the standard packets currently used. In preliminary tests spunbonded polyethylene, a fibrous material, demonstrated resistance to insect penetration and a larger test with 50-lb. bags is under way. Shell cartons in which the inner ply of the flaps contained numerous slits to allow a sandwiched hot-melt adhesive to flow through and form a heat seal provided excellent resistance to insect invasion in a small-scale test. (MQ 1-22)

5. Military Shipping and Storage Test. Multiwall paper bags with the synergized pyrethrins treatment on the outer ply and with tape-over-stitch (TOS) and pasted-open-mouth (POM) closures with heat-sealed adhesives were tested to evaluate the protection against insect infestation in flour they would provide in military shipping and storage channels. After 24 months of storage in a subsistence warehouse at the Naval Supply Center at Norfolk, Virginia, 75% of the stitch-over-tape (SOT) untreated bags and 92% of the treated bags with SOT wax-dipped closures were infested. Only 10% of the treated bags with TOS or POM closures were infested and this was at a very low level. Nearly all the TOS and POM bags remained free of insects during 6 to 9 months in heavily infested simulated warehouse storage at the Savannah laboratory. Seventy percent of the treated bags with SOT wax-dipped closures were infested within 3 months under the same storage conditions. Piperonyl butoxide residues in flour from treated bags never exceeded the established tolerance of 10 p.p.m. (MQ 1-17)

6. Stability of Repellent Treatment. Very little piperonyl butoxide was lost from a mill roll of kraft paper treated with synergized pyrethrins and aged in storage for 1 year. Periodic chemical analyses were made during the year. Treated multiwall kraft bags stored in a bundle lost very little piperonyl butoxide but there was a rather rapid movement from the outer to the inner plies of the bags. (MQ 1-17)

7. Insect-Resistant Cotton Bags. In cooperative work with the Southern Utilization Laboratory, cotton bags treated with synergized pyrethrins, with a waxed-kraft liner, cemented side seams, and tape-over-stitch end closures were effective in preventing insect infestation of the contents for 9 months of storage in a heavily-infested test room. The piperonyl butoxide residues in flour or cornmeal were 10 p.p.m. or less for a treatment at 60 mg. per sq. ft. but exceeded 10 p.p.m. at 120 mg. per sq. ft. The bags were 100-lb. size and were stacked to simulate warehouse storage in a large-scale test. Included in the test were other experimental cotton bags without the liner, with regular sewn seams and closures, with kraft tape heat-sealed over seams and closures, and treated with different

amounts of synergized pyrethrins. These bags gave some degree of protection as the level of treatment was increased but the piperonyl butoxide residues in the flour or cornmeal far exceeded 10 p.p.m., the tolerance set for the use of treated paper bags. Plans are being developed for field and overseas shipping tests for the treated cotton bag with the liner.

(MQ 1-36)

Laboratory tests of residue barriers for use in treated cotton bags indicate that polypropylene film, saran-coated polypropylene, saran-coated kraft paper, and greaseproof paper may be effective barriers against residue migration into packaged commodities. Heat sealing the saran-coated kraft or polypropylene to the cotton appeared to reduce the barrier properties of the saran coating.

(MQ 1-1(Rev.))

F. Simplified pesticide residue analytical methods

1. Portable Kit for Field Analyses. Screening methods suitable for field use were developed for residues of chlorinated hydrocarbon, organophosphate, and carbamate insecticides, and for chlorinated herbicides in raw and processed foods. There is sufficient cleanup and extraction to detect a pesticide at the FDA tolerance level or at 0.1 p.p.m., whichever is higher. In many cases levels below 0.1 p.p.m. can be detected. Procedures vary for cleanup, extraction, and detection, depending upon the class of pesticide and the type of food. The complete procedure for a chlorinated hydrocarbon in most foodstuffs requires about 1½ hours for one sample. Experience and training would enable an operator to analyze more than one sample at a time or concurrently operate systems from more than one kit to increase the number of samples analyzed in one day. The kit as produced for and demonstrated to the Department under the research contract consists of 3 cases. One contains the hardware and equipment, the other 2 the glassware and sufficient chemicals for one day of operation. The equipment operates independently of any external power supply. It is in the prototype stage and now available commercially. The system could be used as it is now for some specific purposes. Further exploration is required to determine its full potential. Some elements of the system may be changed by results from further research now in progress on analytical procedures.

(MQ 1-50(C))

2. Portable Gas Chromatograph. Substantial progress has been made toward developing analytical procedures for a self-sustaining portable laboratory with gas chromatography as the final step for determining pesticide residues in food and feed. Complete processing of a sample is currently accomplished with less than 100 ml. of total solvents. Hydrolysis of sample matrix and the use of high processing temperatures have been avoided to maintain simplicity and speed. Operating temperature for

chromatographic analysis is 180° C., which is below the 200° limit that was desired. Chromatographic separation of all test pesticides can be accomplished in 10 minutes and processing prior to chromatography may require about 20 minutes. Tests with some residues in wheat, apples, and tomatoes suggest a sensitivity of 0.025 to 0.06 p.p.m. (MQ 1-55(C))

3. Rapid Extraction and Cleanup. The feasibility was demonstrated of using liquid-solid column chromatography as a separation and analytical method for some chlorinated hydrocarbon pesticides. Suitable techniques were developed for blending the sample with the solvent and for separating a clear extract in a single chamber. A new substrate for thin-layer chromatography (TLC) and a scanner for TLC plates were developed. There are indications that a large part of the cleanup can be accomplished by TLC, which is also effective as the separation method. It appears possible to automate the individual steps of cleanup, separation, and detection. Current effort is devoted to that end. (MQ 1-58(C))

4. Immunological Analytical Method. The first evidence of antibody formation against insecticide derivatives has now been obtained, after a number of unsuccessful attempts through several different approaches. The sera from rabbits inoculated with DDA-FBN (dichlorodiphenyl acetic acid-bovine fibrinogen) agglutinated both fibrinogen and DDA-FBN. The latter was agglutinated even after absorbing the sera with fibrinogen. In addition, DDA inhibited the agglutination of DDA-FBN. It appears that there is recognition of DDA, or the DDA-protein linkage. The antibodies observed are of the inhibiting type. No cross reaction was found with DDT, and this compound did not inhibit the agglutination of DDA-FBN. These findings indicate that detection of pesticide-like molecules by immunochemical methods is feasible. Attempts will now be made to accomplish a cross reaction with DDT.

Preliminary results using rabbits inoculated with MLT-FBN (malathion mono ester-bovine fibrinogen) show the sera to react with fibrinogen and MLT-FBN. The nature of this reaction, and whether there is specific recognition of malathion, are now being investigated. (MQ 1-62(C))

G. Fate and effects of pesticide residues

During the reporting period 4,724 analyses were made in support of the entomological research program. An additional 746 analyses were conducted to determine bromide, chloride, and phosphine fumigant residues in wheat, milling fractions, dough, bread, and rolls to learn the effects of repeated fumigation of stored wheat on quality and nutritional factors. The latter is a cooperative study with the Human Nutrition Research Division. Some time was also spent on improving and developing analytical procedures. (MQ 1-29)

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- Press, A. F., Jr., F. O. Marzke, and G. C. Pearman. 1967. Mortality of Trogoderma glabrum larvae in simulated wheat storages purged with carbon dioxide or nitrogen. (Abstract, Bul. Ent. Soc. Amer. 12(3): 305, 1966.) Jour. of Econ. Ent. 60(2): 415-416. (MQ 1-60)
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- Whisenant, Bill R., and U. Eugene Brady. 1967. Effects of anesthesia on the subsequent mating behavior of Plodia interpunctella males. Jour. Georgia Ent. Soc. 2(1): 27-30. (MQ 1-46(Gr))

Biology, Ecology, Physiology, and Nutrition

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- Bry, Roy E., and Joe E. Lang. 1966. Damage to mattress ticking by cigarette beetle larvae. Jour. Georgia Ent. Soc. 1(4): 21-23. (MQ-1)
- Harein, Phillip K., and Edwin L. Soderstrom. 1966. Coleoptera infesting stored products. In Insect Colonization and Mass Production. Edited by Carroll N. Smith. pp. 241-257. Academic Press, New York and London, 618 pp. (MQ-1)

Improved Pesticidal Control

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Insect-Resistant Packaging

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AREA 14

INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities, including instruments to measure color, moisture content, texture, maturity, composition, and to detect defects in a wide range of commodities. Inspection and grading services, food handlers and processors, and research workers in the broad field of agricultural marketing could make use of instruments of this kind. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with other units of the Division.

The Federal scientific effort devoted to research in this area totals 11 scientist man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientist man-years in this section are included in the 12 commodity areas.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality1. Electrical Properties.

(a) Corn moisture measurements. The radio frequency power absorption of individual kernels of corn has been measured and correlated to moisture content. This measurement is made by dropping the sample through a coil carrying a radio frequency current. The sample is not

damaged as was necessary in measuring the electrical conductivity by the previous method. The radio frequency absorption measurement requires less expensive components for the instrumentation but the results have not been as reliable as for the conductivity method. Both methods will now be evaluated to choose the method to be adopted for the final instrument to evaluate the moisture variation within a sample of corn.

(b) Fruit and vegetable measurements. Techniques for evaluating the electrical properties of fruits and vegetables over a wide frequency range are being developed. Initial tests with flesh from apple shows a progressive decline in resistivity as the frequency increases from 10 to 100,000 Hz (6500 ohm-cm at 10 Hz to 900 ohm-cm at 100,000 Hz). By keeping the potential across the tissue low (4.0 volts/cm), stable readings are obtained over several minutes. Measurements of electrical properties are now being made on fruit of varying quality to determine the degree of correlation between electrical properties and selected quality factors. (MQ 3-90(GR))

2. Light Transmittance Techniques.

(a) Oil and moisture analysis of soybeans. An infrared absorption technique has been developed for rapid accurate analysis of both oil and moisture content of soybean flour. The absorption at four wavelengths is measured on a 2-gm sample of soybean flour mixed with 1-1/2 ml of carbon tetrachloride. The absorption difference between 1.80 and 1.94 microns indicates moisture content. The moisture content is determined with an accuracy of ± 0.1 percent. The accuracy of oil determination is still to be determined.

(b) Fat and moisture analysis of meat. The infrared absorption technique has also proven useful in indicating the fat and moisture content of processed meat. The difference in optical density between 1.80 and 1.725 microns gave a high correlation ($r = 0.977$) with moisture content and the difference between 1.725 and 1.65 microns gave a high correlation ($r = 0.974$) with fat content. These measurements were made on meat emulsions and included raw and cooked samples, as well as commercial samples. This direct spectrophotometric analysis predicted fat content within a standard error of $\pm 2.1\%$ and moisture content within $\pm 1.4\%$.

3. Physical Properties of Fruits.

(a) Physical properties of pome fruits that affect equilibrium position. The physical properties of size, shape, weight, density, etc., of pome fruits are being cataloged to provide information needed in the design of automatic machines for handling and sorting of the fruit. Physical properties which have been cataloged include: specific gravity, coefficient of friction on different surfaces, orientation in water, position of center of gravity, volume, surface

area, mean radius, surface roughness, and size and shape of stem and calyx indentations. The properties have been measured on McIntosh apples from New York and Michigan, Red Delicious apples from Washington and Michigan, Rome apples from Washington, and Jonathan apples from Michigan. The variability within varieties, between varieties, and between producing areas have been determined. Additional physical properties are being evaluated in the same way. (MQ 3-87 (C))

4. Sonic Resonance Techniques. The mechanical properties of the flesh of fruits and vegetables are often the chief determinant of fruit texture. The elastic characteristics (modulus of elasticity) and the inelastic properties (internal friction) of some fruits and vegetables were measured during various stages of development. Modulus of elasticity has been reported to be linearly related to the turgor pressure within plant cells. In terms of the textural attributes of whole fruits and vegetables, we have argued that it should be most closely correlated with "firmness" even though some relationship to "crispness" may also exist. Because of the lack of objective definitions for these words, they are not as accurate or useful as one might desire for reporting research results.

Softening of bananas during ripening was associated with a decrease in Young's modulus of elasticity from 272×10^5 to 85×10^5 dynes/cm² as the peel color changed from light green to yellow. Modulus of elasticity was significantly and directly correlated with percent starch content. During ripening, internal friction increased from 0.073 to 0.165, being inversely correlated with the elastic modulus ($r = -0.88$, $df = 58$).

For late Elberta peaches, the modulus of elasticity decreased rapidly from 1925×10^5 dynes/cm² 3 weeks prior to the estimated date of maturity to 195×10^5 dynes/cm² 2 weeks after estimated maturity. Kieffer pears exhibited a more gradual decline from 2884×10^5 to 1151×10^5 dynes/cm² over a 3-month period of development and maturation. For apples, Young's modulus of elasticity generally declined during the early period (90 to 115 days after full bloom), then remained relatively unaffected as the fruit approached maturity, and finally, declined as the fruit ripened on the tree.

With the exception of apples, therefore, the fruits studied exhibited a decreasing modulus of elasticity with advancing stages of development, maturation, or ripening. This mechanical parameter, therefore, may be useful in the future as a more objective and better defined index of firmness, or possibly for estimating stage of maturation or ripeness of fruits.

Recent efforts have been devoted to techniques for measuring sonic resonance within whole intact commodities. An exploratory taste panel's evaluations of ten apples from 2 different storage conditions

indicated the frequency of resonance was more highly correlated with texture ($r = 0.86$) than with juiciness ($r = 0.79$). Of a variety of objective measurements which were compared with the sonic resonant frequency technique, the "mechanical thumb" force was best correlated ($r = 0.79$).

Under a research contract, the proposed "acoustic maturity constant" was evaluated for three varieties of apples. This constant, f^2m , combines the square of the resonant frequency and the mass of the apple. Apples harvested over a 7-week period gave a correlation coefficient of 0.84 between f^2m and Magness-Taylor pressure value, but only 0.12 between f^2m and soluble solids. Thus it appears the f^2m value may provide a good indication of apple firmness, but not of maturity. Previous tests had also shown the f^2m value to correlate with firmness.
(MQ 3-72 (C))

5. New Instruments.

(a) Four-filter photometer for the near infrared region. A four-filter photometer has been developed to make the absorption difference measurements needed for indicating oil and moisture content of oilseed flour or for fat and moisture content of meat emulsions. The instrument uses narrow-band interference filters to isolate the wavelengths to be measured. It is capable of making measurements at any wavelength in the 0.8 to 2.5 microns on dense light-scattering samples having absolute absorbancy of less than 4. Absorption differences as small as 0.001 can be measured. This instrument is now being calibrated for oil and moisture analysis of soybeans.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality.

Finney, Essex E. Jr., and Carl W. Hall. 1967. Elastic properties of potatoes. Transactions of the American Society of Agricultural Engineers, Gen. Ed. Vol. 10 (1): 4-8.

Finney, Essex E. Jr., and Karl H. Norris. 1967. Sonic resonant methods for measuring properties associated with texture of Irish and sweet potatoes. Proceedings of the American Society of Horticultural Science, 90: 275-282.

Norris, Karl H. 1966. Current physical instrumentation with possible application to meat research. Proceedings, 19th Annual Reciprocal Meat Conference of the American Meat Science Association, Cornell University, Ithaca, New York, pp. 34-40.

Biophysics.

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AREA 15

PIONEERING RESEARCH - MARKET QUALITY

Problem. Fresh fruits and vegetables are still living organisms after harvest and continue many vital processes that involve biochemical and physiological changes and activities. Rate of ripening, aging and susceptibility to disease are factors greatly influencing the storage and marketing life and the quality of fruits and vegetables. Since fundamental processes in the plant tissues in a large measure govern these changes a continuing need exists for more basic information on post-harvest physiology, including enzymatic activities, the biosynthesis and function of various natural occurring volatiles; reactions of mitochondria including the electron transport chain, the cytochromes, and other factors associated with respiration and its regulation. This information should furnish a basis for a better understanding of the fundamental behavior of agricultural commodities, and result in improved quality in the products that reach the consumer.

USDA PROGRAM

The Department has a continuing program at Beltsville, Maryland, involving plant physiologists and chemists engaged in basic studies directed toward developing information on the physiological and biochemical changes that occur in fruits and vegetables and other plant material after harvest under conditions that may be encountered in transportation, storage and marketing. This work supplements and is cooperative with other marketing research in the Division.

The Federal scientific effort devoted to research in this area totals 3 scientists' man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Postharvest Physiology

1. Ethylene. Earlier work has established that methionine and peroxidized linolenate can serve as precursors of ethylene. Further work in this laboratory has established the biochemical mechanism by which methionine may serve as a substrate for ethylene. During the past year it has been found that propanal, which is a product of peroxidized linolenic acid, is a potent precursor of ethylene in a model ethylene-producing system. Propanal also stimulates ethylene production when incorporated

into tomato tissue slices. Further studies with C-14 labeled propanal should establish unequivocally that propanal gives rise to ethylene.

The vitamin E content of apples was found to increase during development of the fruit on the tree but declined after 4 months in storage. Although vitamin E could serve as an antioxidant for the peroxidation of linolenate no direct correlation between ethylene production and vitamin E content was found. Preliminary results with ethylene and some growth substances indicate that ethylene can halt the action of gibberellin on tissue elongation.

Cooperative studies with G. Cohen, Columbia University, showed that beef and rat livers produce very small quantities of ethylene but that lipid peroxidation of the tissues results in fairly large quantities of ethane and higher hydrocarbon homologues.

2. Electron Transport. Reversed electron transport may be another system, alternate to ATP, for energy conservation in tissue metabolism. Reversed electron transport was demonstrated for the first time in intact plant tissue by using hypocotyl tissue of lima bean seedlings. Mature tissues did not show this phenomenon. The measurements were made with a sensitive spectrofluorimeter built by K. Norris of the Instrumentation Research Laboratory.

3. Electron Microscopy. A Phillips EM-200 electron microscope has been purchased cooperatively with the Crops Research Division. Facilities for glass knife preparation, shadow casting, and the preparation of ultra thin sections have been installed and the entire unit is now operational. Planned studies include membrane and organelle ultrastructure in relation to biochemical activity, developmental stage and cultural treatment of the plant or organ.

4. Chilling Injury. Mahogany browning and other injury symptoms shown by potatoes stored at 0° C. did not develop when the potatoes were warmed intermittently to 15.5°. Cooperative work with the Horticultural Crops Research Branch (MQ 2-92) showed that potatoes had 2.5 to 4 times as much total sugar content when held for 4 months at 0° as compared to those held intermittently at 15.5° for 1 week each month. A yellow fluorescence appeared in potatoes stored at 0°. Fluorescence emission spectra of tissue slices showed a broad spectrum with maxima at 435 and 480 mμ. Fractionation of extracts yielded some fluorescing compounds with maxima at 435 mμ and others with maxima at 480 mμ. Identification of the fluorescing compounds is being attempted.

Work & Line Project Number	Work and Line Project Titles	Work Locations	Progress : (Yes-No)	Area and Subheading
MQ 1	Methods for the prevention and control of insects attacking agricultural products in the marketing channels	Program Leadership: Hyattsville, Md.		
MQ 1-1(R)	Packaging insecticide formulation studies	Savannah, Ga.	Yes	13-E-3,7
MQ 1-7(R)	Ecology of stored-tobacco insects	Richmond, Va.	Yes	11-A-1
MQ 1-9	Infrared rice dryers for insect control*	Fresno, Calif.	No	
MQ 1-12	Physical energy for detecting and controlling insects	Savannah, Ga.	Yes	13-A-1,2,3,5
MQ 1-15	Laboratory evaluation of protectants for commodities	Fresno, Calif.	Yes	3-F-3 4-C-3
MQ 1-16(R)	Forced-distribution fumigation of grain in commercial storages	Manhattan, Kans.	Yes	4-C-3
MQ 1-17	Storage tests of insect-resistant packages	Savannah, Ga.	Yes	13-E-5,6
MQ 1-19	Protective treatments for rough rice	Fresno, Calif.	No	
MQ 1-20	Preliminary evaluation of compounds for insect-resistant packages	Savannah, Ga.	Yes	13-E-1
MQ 1-21	Preliminary storage tests of insect-resistant package treatments	Savannah, Ga.	No	
MQ 1-22	Physical resistance of packages to insects	Fresno, Calif.	Yes	3-F-4 13-E-4
MQ 1-23	Preliminary evaluation of insecticides	Savannah, Ga.	Yes	13-B-9 13-C-2 13-D-1 13-D-5
MQ 1-25	Spray applications for warehouses	Savannah, Ga.	Yes	13-D-2
MQ 1-26	Laboratory evaluation of mothproofing compounds	Savannah, Ga.	Yes	8-B-1 13-D-3
MQ 1-27(R)	Intermediate evaluation of protectants for commodities	Fresno, Calif.	Yes	3-F-3 4-C-1
MQ 1-28	Laboratory evaluation of fumigants	Savannah, Ga.	Yes	13-D-1
MQ 1-29	Determination of chemical residues	Savannah, Ga.	Yes	13-G
MQ 1-32(C)	Natural attractants in dermestid beetles	Madison, Wis.	Yes	2-B-1
MQ 1-34	Insect control at fruit processing plants	Fresno, Calif.	Yes	3-F-3
MQ 1-35	Toxic and repellent materials for cigarette beetles	Richmond, Va.	Yes	11-A-2
MQ 1-36	Development of insect-resistant cotton bags	Savannah, Ga.	Yes	13-E-7
MQ 1-37	Flowing steam under vacuum to control tobacco insects*	Richmond, Va.	Yes	11-A-1
MQ 1-38	Effects on insects of dockage in wheat	Manhattan, Kans.	Yes	4-C-2
MQ 1-39(C)	Protection of packaged food against pesticide contaminants	Savannah, Ga.	Yes	13-E-3
MQ 1-40(C)	Insect repellents for food packages and grain	Savannah, Ga.	Yes	13-E-2
MQ 1-41(C)	A fumigation and controlled-environment chamber	Savannah, Ga.	Yes	13-D-4
MQ 1-42(Gr)	Host finding and parasitization performance by a hymenopterous parasite	Hyattsville, Md.	Yes	13-A-8
MQ 1-43(Gr)	Oxidative detoxication enzymes in insects	Savannah, Ga.	Yes	13-C-1
MQ 1-44(Gr)	Bionomics of the Indian-meal moth	Savannah, Ga.	Yes	13-B-6
MQ 1-45(Gr)	Effects of gamma radiation on mites	Savannah, Ga.	Yes	13-A-5
MQ 1-46(Gr)	Sex-attractant pheromone in the Indian-meal moth	Savannah, Ga.	Yes	13-A-7
MQ 1-47(Gr)	Effects of sound on the Indian-meal moth	Savannah, Ga.	Yes	13-A-3
MQ 1-48(Gr)	Low temperature adaptation and chill-coma in stored-product insects	Savannah, Ga.	Yes	13-B-7
	Continued next page			

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Inc. in Summary of: Progress (Yes-No)	Area and Subheading
MQ 1-49(Gr)	: Factors affecting sorption and retention of quaternary ammonium mothproofing compounds	: Savannah, Ga.	: Yes	: 8-B-1
MQ 1-50(C)	: Methods for detection of pesticide residues*	: Hyattsville, Md.	: Yes	: 13-F-1
MQ 1-53	: Mitochondrial metabolism in the Indian-meal moth	: Savannah, Ga.	: Yes	: 13-B-1,2
MQ 1-54(Gr)	: Life history and bionomics of <u>Trogoderma</u> species	: Hyattsville, Md.	: Yes	: 13-B-8
MQ 1-55(C)	: Development of portable gas chromatograph	: Hyattsville, Md.	: Yes	: 13-F-2
MQ 1-56	: Effect of photoperiod and temperature on the Indian-meal moth	: Savannah, Ga.	: Yes	: 13-B-3
MQ 1-57	: Sound receptors in stored-product insects**	: Savannah, Ga.	: No	:
MQ 1-58(C)	: Rapid extraction and cleanup for residue analysis	: Hyattsville, Md.	: Yes	: 13-F-3
MQ 1-60	: Controlled atmospheres to protect stored products against insect damage**	: Savannah, Ga.	: Yes	: 6-C-1
		: Tifton, Ga.	:	: 4-C-1
MQ 1-61(C)	: Mothproofing procedures using quaternary ammonium compounds	: Savannah, Ga.	: Yes	: 8-B-1
MQ 1-62(C)	: Development of antibody reactions specific for pesticides	: Hyattsville, Md.	: Yes	: 13-F-4
MQ 1-63(Gr)	: Host specificity in stored-product insects	: Hyattsville, Md.	: Yes	: 13-A-6
MQ 1-64(Gr)	: Effects of sorghum varieties on development of two species of rice weevils**	: Hyattsville, Md.	: No	:
	: *Discontinued during reporting period	:	:	:
	: **Executed during reporting period	:	:	:
	:	:	:	:

Line Project Check List -- Reporting Year July 1, 1966 to June 30, 1967

Work & Line	:	:	:	Line Proj. Incl. in
Project	:	:	:	Summary of:
Number	:	Work and Line Project Titles	Work Locations During Past Year	Progress: Area and (Yes-No): Subheading
MQ 2	:	Maintaining and improving agricultural product	:	:
	:	quality in storage, transportation, and handling	:	:
	:	Program Leadership	:	:
MQ 2-7 (R)	:	Cause and development of control of microbiological, chemical and physical deterioration of rough rice in relation to off-farm conditioning, handling and storage in the South Central States	:Hyattsville, Md. : College Station, Texas :	: Yes : 4a-B-1
MQ 2-29	:	Detection and description of freezing injury*	:	: No :
MQ 2-44	:	Methods of long-term storage of vegetable oils in relation to oil quality	:Washington, D. C. :	: Yes : 6-B-1
MQ 2-55	:	Transit temperatures - California potatoes*	:	: No :
MQ 2-62	:	Microbiological deterioration of grass seeds during marketing*	:	: No :
MQ 2-63	:	Plastic film for eastern fruit*	:	: No :
MQ 2-64	:	New market diseases	:Belle Mead, N.J. :	: Yes : 1-E-3
	:		:Miami, Fla., :	: : 1-F-4
	:		:Chicago, Ill., & :	: : 12-F-8
	:		:Beltsville, Md. :	: : :
MQ 2-65	:	Postharvest diseases of Florida citrus	:Lake Alfred, Fla. :	: Yes : 1-B-1
	:		:Orlando, Fla. :	: : 1-F-1
MQ 2-67	:	Forecasting storage diseases of apples	:	: No :
MQ 2-69	:	Storage temperatures and processing quality of potatoes*	:	: No :
MQ 2-70	:	Evaluation of microbiological, chemical and physical deterioration of corn in storage and the development of methods and procedures to prevent or minimize such quality loss	:Beltsville, Md. :	: Yes : 4-B-1
MQ 2-71	:	High nitrogen or carbon dioxide in shipments of fruits and vegetables*	:	: No :
MQ 2-74	:	Florida grapefruit on European markets*	:	: No :
MQ 2-75	:	Development of improved methods for maintaining meat quality in market channels	:	: No :
MQ 2-76	:	Cause and prevention of heat damage in rough rice in relation to off-farm conditioning, handling and storage in the South Central States	:	: No :
MQ 2-78	:	Bruising of potatoes during handling into storage	:	: No :
MQ 2-80	:	Prepackaged vegetables	:Belle Mead, N.J. :	: Yes : 12-B-1
	:		:Fresno, Calif. :	: : 12-B-2
MQ 2-81	:	Quality retention of eviscerated poultry as related to method of slaughter	:	: No :
MQ 2-83	:	Transit environments on western strawberries	:Fresno, Calif. :	: Yes : 3-C-1
	:		:Belle Mead, N.J. :	: : 3-C-2
	:		:	: : 3-C-3
	:		:	: : 3-E-4
MQ 2-84	:	Fruits and vegetables in mechanically refrigerated cars and trailers	:Fresno, Calif. :	: Yes : 12-D-3
	:		:Belle Mead, N.J. :	: : 12-D-4
MQ 2-86	:	Chilling injury of eggplant*	:	: No :
MQ 2-89	:	Storage of asparagus crowns*	:	: No :
MQ 2-90	:	Effects of heat treatments on potato diseases	:Presque Isle, Me. :	: Yes : 9-E-1
MQ 2-91	:	Apple and pear scald	:Beltsville, Md. :	: Yes : 3-D-1
	:		:Wenatchee, Wash. :	: : 3-D-2
MQ 2-92	:	Ventilation rates and humidity of potatoes	:Presque Isle, Me. :	: Yes : 9-C-1
MQ 2-93	:	Prestorage and handling of Maine potatoes	:Presque Isle, Me. :	: Yes : 9-B-1
MQ 2-94	:	Composition and maturity of blueberries	:Raleigh, N. C. :	: Yes : 3-E-3
MQ 2-95	:	Decay of onions in storage	:Belle Mead, N. J. :	: Yes : 12-F-1

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress (Yes-No)	Incl. in Area and Subheading
MQ 2-96	Radiation and pathogenicity of fungi	Chicago, Ill.	Yes	3-E-9
MQ 2-97	Proteolytic enzymes in relation to market decay	Belle Mead, N.J.	Yes	3-E-10
MQ 2-98	Citrus fruit in CA storage	Pomona, Calif.	Yes	1-C-2
		Harlingen, Texas		1-C-3
MQ 2-99	CA storage of stone fruits	Beltsville, Md.	Yes	3-B-1
		Wenatchee, Wash.		3-B-2
MQ 2-100	Components of citrus rind affecting decay organisms	Orlando, Fla.	Yes	1-F-2
MQ 2-101	Infection of table grapes	Fresno, Calif.	Yes	3-E-2
MQ 2-102	Ozone on fruits and vegetables*	Beltsville, Md.	Yes	3-E-7
MQ 2-103	Development of mycotoxins in peanuts and rice as related to off-farm handling	College Station, Texas	Yes	4a-B-3
				6-B-2
MQ 2-104	Heat treatments to control decay of fruits	Beltsville, Md.	Yes	3-E-5
MQ 2-105	CA effects on cut flowers	Beltsville, Md.	Yes	11b-A-1
		Fresno, Calif.		11b-B-2
				11b-B-3
				11b-B-4
				11b-C-1
MQ 2-106(C)	Effects of storage temperatures on quality of vegetable salad oils	Washington, D.C.	Yes	6-B-3
MQ 2-107	Market quality of peanuts as affected by improving methods, techniques, equipment and facilities for handling, conditioning and storage of farmers' stock and shelled peanuts	Raleigh, N. C.	Yes	6-B-2
		Albany, Ga.		
MQ 2-108	Effect of ambient conditions of storage on the presence and increase of molds and aflatoxins in cottonseeds	Beltsville, Md.	Yes	7-B-3
		Washington, D.C.		
MQ 2-109(C)	Postharvest microflora of tobacco and its effect on tobacco composition	Lexington, Ky.	Yes	11-B-1
MQ 2-110	CA for citrus and other subtropical fruits	Orlando, Fla.	Yes	1-C-1
		Miami, Fla.		1-C-4
MQ 2-111	Translucent scales of midwestern grown onions		No	
MQ 2-112	Atmospheric modification and postharvest decay	Fresno, Calif.	Yes	3-E-8
MQ 2-113(C)	Microbiology of "further processed" turkey products	Beltsville, Md.	Yes	10-B-5
MQ 2-114	Heat treatment of figs**	Fresno, Calif.	Yes	3-E-6
MQ 2-115	Aflatoxin production in cottonseed	College Station, Texas	Yes	7-C-1
MQ 2-116	Effectiveness of chlorine in controlling decay	Orlando, Fla.	Yes	12-F-5
MQ 2-117	Maintaining quality in Florida-grown cut flowers		No	
MQ 2-118	Respiration and ethylene production in cut flowers		No	
MQ 2-119(CA)	Mycotoxin fungi in stored corn		No	
MQ 2-120(CR)	Relation to microflora to quality of grains and their products		No	
MQ 2-121	Sanitary quality and wholesomeness of further processed poultry products		No	
MQ 2-123	Cruciferous vegetables held in controlled atmospheres	Fresno, Calif.	Yes	12-C-3, 12-C-5
MQ 2-124	Stem and neck rot of Anjou pears	Wenatchee, Wash.	Yes	3-E-1
MQ 2-125	Fungicides for apples and pears	Wenatchee, Wash.	Yes	3-E-11
MQ 2-126	CA on decay organisms	Pomona, Calif.	Yes	1-F-3
MQ 2-127	Cooling methods and rates on storage life of apples	Wenatchee, Wash.	Yes	3-B-3
MQ 2-128	Sweetpotato storage under modern methods of handling	Raleigh, N. C.	Yes	12-C-1

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Work & Line Project Number	:	:	:	Line Proj. Incl. in
	:	:	:	Summary of :
	:	Work Locations	Progress	Area and
	:	During Past Year	(Yes-No)	Subheading
MQ 2-129	:Pectolytic, proteolytic, and lipolytic :enzymes**	:Beltsville, Md.	: Yes	: 12-F-3
MQ 2-130	:Sprout control in potatoes and sweetpotatoes**	:Raleigh, N. C.	: Yes	: 12-C-2
MQ 2-131	:Market diseases of Porto Rico fruits and :vegetables**	:Chicago, Ill.	: Yes	: 12-F-6
MQ 2-132	:Market losses**	:Chicago, Ill.	: Yes	: 1-F-5
	:	:Belle Mead, N. J.	:	: 3-E-13
	:	:	:	: 3-E-14
	:	:	:	: 3-E-15
	:	:	:	: 9-E-2
	:	:	:	: 12-F-7
MQ 2-133	:Bacterial soft rot of peppers**	:Harlingen, Texas	: Yes	: 12-F-2
MQ 2-134	:Reduction of molds on cantaloups**	:Harlingen, Texas	: Yes	: 12-F-4
MQ 2-135	:Control of <u>Salmonella</u> on fresh market :poultry**	:	: No	:
MQ 2-136	:Modified atmospheres on vegetables & fruits**	:Fresno, Calif.	: Yes	: 9-D-1
	:	:Davis, Calif	:	: 12-C-6
	:	:Harlingen, Texas	:	: 12-C-7
	:	:	:	: 12-C-8
	:	:	:	: 12-C-9
	:	:	:	: 12-D-1
MQ 2-137(CA)	:Microflora of flue-cured tobacco and their :effect on quality**	:Raleigh, N. C.	: Yes	: 11-B-2
MQ 2-138	:Deterioration of grass seeds in storage**	:Beltsville, Md.	: Yes	: 4b-B-1
MQ 2-139	:Fruits and vegetables to overseas markets**	:Harlingen, Texas	: Yes	: 1-D-1
	:	:Pomona, Calif.	:	: 1-D-2
	:	:Belle Mead, N.J.	:	: 12-D-2
	:	:	:	:
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	: *Discontinued during reporting period.	:	:	:
	: **Executed during reporting period.	:	:	:

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Inc. in Summary of: Progress (Yes-No)	Area and Subheading
MQ 3-52	Determination of lighting and other visual : environmental requirements for proper : grading and inspection of poultry*	Beltsville, Md.	Yes	10-A-2
MQ 3-53	Seasonal changes in Florida Persian limes	Miami, Florida	Yes	1-A-2
MQ 3-54	Development of techniques and/or devices to : facilitate handling of certain grass seeds : for purity and germination analysis	College Sta., Tex.	Yes	4b-A-5
MQ 3-55	Studies on the physiological and biochemical : factors involved in seed and seedling vigor	Beltsville, Md.	Yes	4b-A-6
MQ 3-56	Raw product factors and processed quality in : potatoes		No	
MQ 3-57	To develop a method of measuring moisture dis- : tribution in butter	Beltsville, Md.	Yes	2-A-1
MQ 3-58	Develop a rapid method for measuring protein : content of sorghum and other feed grains	Beltsville, Md.	Yes	4b-A-7
MQ 3-59	An investigation of the lighting and other : visual environmental requirements for the : proper evaluation of the quality character- : istics of meat	Beltsville, Md.	Yes	5-A-2
MQ 3-60(C)	The relationship of marbling to the palata- : bility of beef	Beltsville, Md.	Yes	5-A-3
MQ 3-61	Flavor studies to provide basis for more : objective and precise standards for meat : palatability		No	
MQ 3-62	Studies to provide a basis for more objective : and precise standards for maturity eval- : uation	Beltsville, Md.	Yes	5-A-4
MQ 3-64(C)	Verification of varietal designations of crop : seed	Beltsville, Md.	Yes	4b-A-8
MQ 3-65(C)	Methods for identifying and evaluating stink- : bug damage in soybeans	Beltsville, Md.	Yes	4-A-2
MQ 3-66(R)	Rapid detection of molds and/or fungal : metabolites in grain, oilseeds and peanuts	Albany, Georgia : Raleigh, N. C. : Beltsville, Md. : Washington, D. C.	Yes	4-A-3, : 6-A-3
MQ 3-67	Detection and identification of seedborne : pathogenic fungi	Beltsville, Md.	Yes	4b-A-9
MQ 3-69(C)	Sample preparation for measuring wool fineness : by Coulter Counter technique	Beltsville, Md.	Yes	8-A-1
MQ 3-70	Improved methods for detection of chlorinated : insecticide residues in animal products and : in livestock feeds	Beltsville, Md.	Yes	2-A-2, : 10-A-3
MQ 3-71(C)	Development and evaluation of an instrument : and techniques for rapid determination of : cotton fiber strength	Clemson, S. C.	Yes	7-A-5
MQ 3-72(C)	Sonic techniques for measuring interior : quality of fruits and vegetables	Beltsville, Md.	Yes	14-A-4
MQ 3-73	Methodology studies for development of spin- : ning performance tests for cotton	Clemson, S. C.	Yes	7-A-6
MQ 3-74	Method for detecting salmonellae in poultry : and egg products	Beltsville, Md.	Yes	10-A-1
MQ 3-76	Improved procedures for direct microscopic : counting of bacteria in milk*	Beltsville, Md.	Yes	2-A-3
MQ 3-77	Instruments for automatically sorting citrus : fruits	Orlando, Florida	Yes	1-A-1
MQ 3-78	Development and evaluation of methods of : identifying mixed lots of corn	Beltsville, Md.	Yes	4-A-4
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Work & Line Project Number	Work and Line Project Titles	Work Locations : During Past Year	Line Proj. Inc. in Summary of: Progress : Area and Subheading
MQ 3-79	:Criteria and tests for evaluating the quality of all-purpose flour	:Beltsville, Md.	: Yes : 4-A-5
MQ 3-80(CA)	:A rapid method for measuring moisture content of cured tobacco	:	: No :
MQ 3-81(C)	:Development of an instrument for rapid determination of cotton color and of trash content separately in a sample of cotton	:Clemson, S. C.	: Yes : 7-A-7
MQ 3-82	:Objective measurements for determining the degree of milling of rice	:College Sta., Tex.	: Yes : 4a-A-1
MQ 3-83	:Temperature and light gradients on seed germination	:Beltsville, Md.	: Yes : 4b-A-10
MQ 3-84	:An apparatus for rapidly mixing and blending a sample of cotton lint	:	: No :
MQ 3-85(C)	:Procedure for evaluation of mechanical grain samplers	:Beltsville, Md.	: Yes : 4-A-6
MQ 3-86(C)	: <u>Erysipelothrix insidiosa</u> infection in market turkeys	:	: No :
MQ 3-87(C)	:Physical properties of pome fruits that affect equilibrium position	:E. Lansing, Mich.	: Yes : 14-A-3
MQ 3-88	:Objective measurements of market quality in raw peanuts	:Raleigh, N. C.	: Yes : 6-A-4
MQ 3-89	:Citrus volatiles as an index of dessert quality	:Pomona, Calif.	: Yes : 1-E-4
MQ 3-90(GR)	:Electrical properties of fruits and vegetables	:W. Lafayette, Ind.	: Yes : 14-A-1
MQ 3-91(C)	:Methods for identifying meat slaughtered by approved methods**	:Hyattsville, Md.	: Yes : 5-A-5
MQ 3-92(C)	:The interrelationships of wool fineness, softness quality and market evaluation of domestic wools	:Beltsville, Md.	: Yes : 8-A-2
MQ 3-93	:Sublethal heat injury and subsequent recovery of psychrophilic bacteria in pasteurized milk**	:Beltsville, Md.	: Yes : 2-A-4
MQ 3-94(CA)	:Development of methods for predicting the storage life of seeds**	:Beltsville, Md. :State College, :Miss.	: Yes : 4b-A-11
MQ 3-95	:Maturity and quality measurement of apples**	:Beltsville, Md. :Wenatchee, Wash.	: Yes : 3-A-1,2
MQ 3-97	:Measuring color of potato chips**	:Beltsville, Md.	: Yes : 9-A-1
MQ 3-99	:Evaluation of the quality of gamma irradiated cereal grains**	:	: No :
MQ 3-100	:Anthocyanins in cherries ** *	:	: No :
MQ 3-101(C)	:Develop a method and a device for isolating and concentrating the germ of grain kernels**	:Beltsville, Md.	: Yes : 4-A-10
MQ 3-102(C)	:Development of a fast, easily calibrated moisture instrument requiring no sample weighing, conversion charts of temperature adjustments**	:Beltsville, Md.	: Yes : 4-A-7
MQ 3-103(C)	:Automatic determination of weight per bushel of grain**	:Beltsville, Md.	: Yes : 4-A-9
MQ 3-104(C)	:Development of a method and/or device to determine the percentage of sound grain in a sample**	:Beltsville, Md.	: Yes : 4-A-11
MQ 3-105(C)	:The use of optical properties to separate a specific grain from other grains and materials in a grain sample**	:Beltsville, Md.	: Yes : 4-A-8
	: *Discontinued during reporting period	:	:
	: **Executed during reporting period	:	:

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress (Yes-No)	Incl. in Area and Subheading
A7-AMS-6 (k)	:Post-harvest diseases of tropical and sub-tropical fruits	:Allahabad, India	: Yes	: 1-F-6
A7-AMS-12 (a)	:Studies in the "Canary Coloration of raw wools"	:Delhi, India	: Yes	: 8-A-3
A7-MQ-1 (a)	:Resistance to two major stored grain pests in world collection of wheat	:New Delhi, India	: Yes	: 4-C-1
A7-MQ-2 (a)	:X-ray analysis of the anatomy and viability of seeds of some economic plants with a view to standardize rapid techniques of value in seed testing	:New Delhi, India	: Yes	: 4b-A-12
A7-MQ-3 (a)	:Investigation on the physiology of the khapra beetle, <u>Trogoderma granarium</u> , with emphasis on fat metabolism	:Baroda, India	: Yes	: 4-C-2
A7-MQ-6 (k)	:Metabolic changes in the storage and ripening of mangos	:Baroda, India	: Yes	: 1-F-2
A7-MQ-7 (a)	:Studies on <i>Aspergillus flavus</i> with special reference to the determination of role of aflatoxin in its metabolism	:Delhi, India	: Yes	: 6-A-5
A7-MQ-12 (a)	:Control of microflora and related production of mycotoxins in stored sorghum, rice and groundnut (peanuts)	:Mysore, India	: No	:
A7-MQ-13	:Significance of enterococci and coliform bacteria in dairy and food products**	:Udaipur, India	: No	:
A7-MQ-17 (k)	:Mycotoxins in cotton: A preliminary survey of the growth of <i>Aspergillus flavus</i> and the production of aflatoxins in cottonseed**	:Hyderabad, India	: No	:
A10-AMS-4 (a)	:Effect of ethylene dibromide fumigated foods and feeds on animals*	:Rehovoth and Beit Dagan, Israel	: Yes	: 4-C-4
A10-AMS-11 (k)	:Influence of environmental conditions on population dynamics of the khapra beetle*	:Jerusalem, Israel	: Yes	: 4-C-2
A10-MQ-1 (a)	:Isolation and structure of germination inhibitors in seeds	:Rehovoth and Jerusalem, Israel	: Yes	: 4b-A-13
A10-MQ-2 (k)	:Investigations of maturation and ripening of avocado fruits	:Rehovoth, Israel	: Yes	: 1-E-1
A10-MQ-4 (a)	:Investigations on the use of antimetabolites for the control of certain stored-product insects	:Jerusalem, Israel	: Yes	: 13-A-10
A10-MQ-5 (a)	:Invisible marking of seeds (vegetable and cereal seeds)	:Beit Dagan, Israel	: Yes	: 4b-A-14
A10-MQ-6 (k)	:Biological basis of physiological phenomena in seed germination**	:Jerusalem, Israel	: Yes	: 4b-A-15
A10-MQ-11 (k)	:Active substances produced by the khapra beetle and their role in mixed populations of stored pests**	:Jerusalem, Israel	: No	:
A11-MQ-2 (a)	:Toxic metabolites development in rice as a result of invasion and growth of species of <i>Penicillium</i> during post-harvest conditioning, handling, and storage	:Tokyo, Japan	: Yes	: 4a-B-3
A11-MQ-3 (a)	:Constituents of rice, wheat, and dairy products that attract insects.	:Tokyo, Japan	: Yes	: 2-B-1 4a-C-1
E8-AMS-5 (a)	:The effect of atmospheres with various concentrations of added carbon dioxide or nitrogen upon the properties of refrigerated meat	:Helsinki, Finland	: Yes	: 5-B-1
:	:	:	:	:
:	:	:	:	:

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in Summary of Progress (Yes-No)	Area and Subheading
E8-AMS-6 (a)	:Studies on the effects of pesticides on the storage life, chemical composition, food quality, and nutritive value of plant commodities	:Helsinki, Finland	: Yes	:3-D-3
E10-AMS-3 (a)	:Investigations about the antimicrobial action of biphenyl and derivatives of biphenyl on citrus fruit spoilage organisms	:Munich, Germany	: Yes	:1-F-7
E10-MQ-1 (a)	A study of methods for maintaining the germination of seeds over long periods of time	:Reutlingen, Germany	: Yes	:4b-B-2
E10-MQ-3 (a)	:Biological and environmental factors affecting the physiological maturity of grass seeds	:Munster, Germany	: Yes	:4b-A-16
E15-AMS-12(a)	:The effect of long-term bulk storage upon quality of edible vegetable oils.	:Florence, Italy	: Yes	:6-B-4
E19-AMS-11(a)	:The health condition of seeds in commercial channels: Development of methods suitable for routine testing of seed for seedborne organisms	:Wageningen, Netherlands	: Yes	:4b-A-17
E19-MQ-1 (a)	:Kernel hardness and its relation to mechanical and technological properties of wheat and flour	:Wageningen, Netherlands	: Yes	:4-A-12
E21-AMS-4 (a)	:Studies on the possibility of using <i>Bacillus thuringiensis</i> for the control of the Indian meal moth, <i>Plodia interpunctella</i> (Hbn.), or the Mediterranean flour moth, <i>Ephestia kuhniella</i> *	:Poznan, Poland	: Yes	:13-A-9
E21-MQ-1 (a)	:Ecology of mites attacking dried fruits and herbs	:Warsaw, Poland	: Yes	:3-F-2
E21-MQ-2 (k)	:The origin and characterization of mustiness in wheat**	:Poznan, Poland	: No	:
E25-AMS-6 (k)	:The detection of additives in citrus juices	:Valencia, Spain	: Yes	:1-A-3
E25-AMS-7 (a)	:Development and evaluation of equipment and methods for determining the proportions of durum wheat (semolina) and common wheat (farina) in macaroni and spaghetti products.	:Madrid, Spain	: Yes	:4-A-13
E25-AMS-8 (a)	:Study of changes occurring in egg whites during cold storage	:Madrid, Spain	: Yes	:10-B-7
E25-AMS-9 (a)	:Basic studies on aging of milled rice and application to discriminating quality factors	:Valencia, Spain	: Yes	:4a-B-2
E30-MQ-1	:The effectiveness against stored-product insects of inert dusts, insect pathogens, temperature, and humidity**	:Zagreb, Yugoslavia	: No	:
S3-AMS-2 (k)	:Substrate moisture levels for germination testing of agricultural seeds*	:Sao Paulo, Brazil	: Yes	:4b-A-18
S9-AMS-6 (a)	:Underground storage of corn in airtight silos*	:Montevideo, Uruguay	: Yes	:4-C-1
:	:	:	:	:
:	:	:	:	:
:	: *Discontinued during reporting period	:	:	:
:	: **Executed during reporting period	:	:	:

